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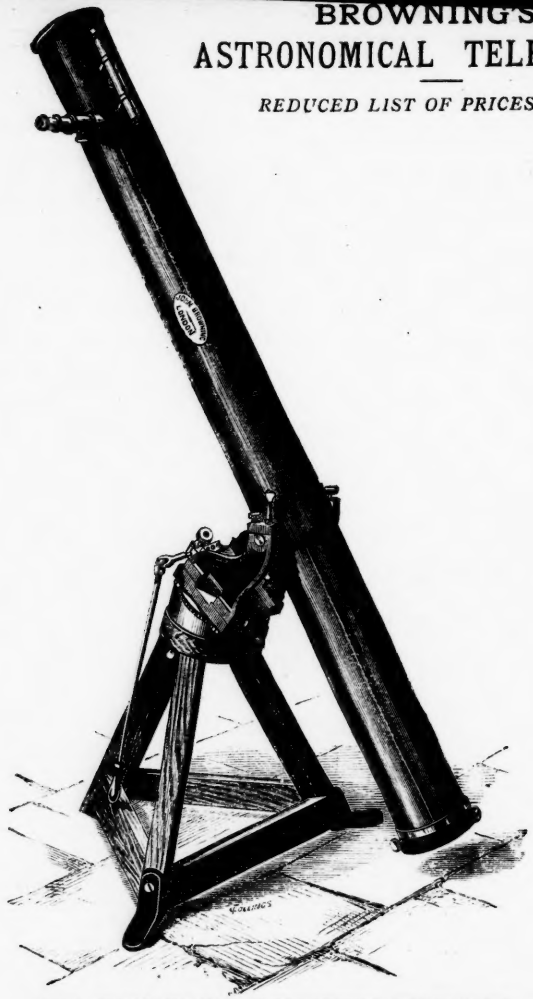

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XUM

THE

JOURNAL OF SCIENCE.

FEBRUARY, 1880.

I. THE LONDON WATER-SUPPLY.*

BY way of justification for introducing this subject we need merely say that the water-supply of London—a matter affecting the well-being, physical, economical, and in some sense even moral, of more than one-tenth part of the population of the home kingdoms—is no insignificant part of the "condition of England question." As such it may well claim the serious consideration of the public, unless in these days of hysterical sensationalism we have utterly abandoned all pretension to be a practical people. We shall do well to remember, further, that every year aggravates the evils with which the metropolis is now beset, and renders their ultimate abolition more and more difficult and costly.

The water-supply of any community, and certainly of so vast a city as London, should, we submit, conform to the following conditions:—In the first place the available quantity should be far in excess not merely of the actual demand, but of any total likely to be reached in the future, in accordance with the increase of the population. Secondly, the supply should be not intermittent, but continuous. Thirdly, the quality of the water should be unimpeachable. And

* On the Supply of Water to London from the Sources of the River Severn. By J. F. BATEMAN, C.E., F.R.S., F.G.S., &c. London: Vacher and Sons.

On a Constant Water-Supply for London. By J. F. BATEMAN, C.E., F.R.S., F.G.S., &c. London: Vacher and Sons.

On the Supply of Water to London. By G. A. ROWBOTHAM. London: printed for private circulation.

Water and Water-Supply. By Prof. D. T. ANSTED, F.R.S., F.G.S. London: W. H. Allen and Co.

lastly, the management and property of the supply should be vested in an elective local authority, directly responsible to the rate-payers.

The first of these requirements will not, we presume, give rise to any discussion. All will admit that the consumption of water for purposes domestic, manufacturing, sanitary, and ornamental, is likely to increase even more rapidly than in a direct ratio to the population. One only economy is possible: were Macadamised roads, as they ought to be, banished from all urban districts, the floods of water daily spent in converting their stratum of dust into mire, to the promotion of evil odours, might be a great part saved.

Our second requirement also will scarcely be called in question, at least by the only parties entitled to be heard, namely, the consumers. On this subject Mr. Bateman remarks that, where the constant system is in vogue, "the first cost of introducing the water is reduced to the lowest possible point, and the pollution which more or less commonly attends the storage of water in house cisterns is entirely prevented; the water is delivered in the purest, freshest, and coolest condition, and very much of the annoyance and inconvenience arising from frozen cisterns and burst pipes is avoided. There is no occasion for exposed pipes in out of the way places—for cisterns, in roofs, or on the top of houses—to be filled with soot and dust in summer, and to be frozen in winter; and a man may live in tolerable comfort without the dread of the water bursting above his head." Another defect of the intermittent system is that in case of a fire there is often no water in the mains, and precious time is lost while the turncock is being fetched to the scene of action. In a warm summer—an event rare indeed, but still within the range of possibility—we have known the water drawn from a house-top cistern in London to mark 71° F. It is needless to show at length that water exposed at such temperatures to contact with so promiscuous a mixture as town dust cannot be fit for human consumption. As regards those who undertake to supply water, it may justly be said that if they feel unable to conform with indispensable conditions they are bound to withdraw in favour of those who can. But Mr. Bateman shows that in his wide experience a constant water-supply by no means involves waste. We incline to think that the loss involved by the intermittent system is the greater. Ball-cocks are often out of order, or are purposely tied down, so that after the cistern is full the water rushes out at the escape-pipe until it is turned "off" at the main.

On the third condition, the quality of the water, considerable difference of opinion prevails. All authorities appear to agree that the presence of animal and vegetable matter in certain states of decomposition, and that of certain low organisms, such as bacteria, are occasionally injurious, and even destructive, to life. As Science is not yet able to say, with any approach to precision, under what circumstances such putrescent matter and such organisms become dangerous, the only safe rule is to insist, as far as possible, on the total absence of all organic matter whatsoever.

But when we come to consider the mineral or inorganic matters from which no natural water is absolutely free, we find certain chemists, engineers, and physicians who advocate a soft water,—*i.e.*, one in which the mineral matters, and especially the salts of lime and magnesia, are at a minimum. Others, again, no less strongly give the preference to the hard waters containing a large proportion of these same calcareous and magnesian salts.

Mr. Bateman regards softness as a very important requisite for the supply of any town; and after a careful consideration of the various purposes, domestic and manufacturing, to which water is applied, we feel compelled to take the same view. Hard water in the household may be pronounced an almost unmixed evil. It appears probable that in London alone the waste of soap, due to the use of hard waters, reaches the annual value of £500,000. To wash the person with hard water is a true penance. The soap is decomposed, and the lime-soap generated forms a film over the skin and blocks up the pores, so that the effects of the operation are the very opposite of what we aim at in our ablutions. We have the high authority of the late M. Soyer for asserting that in all culinary operations, and especially in the boiling of vegetables, better results are obtained with soft than with hard water.

It is very satisfactory to find that Professors Frankland, Odling, Ramsay, and Way, and Drs. Farr, Lyon Playfair, and Simons coincide in this preference for soft water.

On the other hand, Prof. Ansted considers it "certain that among the healthiest towns in England are some of those supplied with hard water containing both carbonates and sulphates." If we remember, however, that the quality of the water supplied to a town is only one of the many factors on which its sanitary condition depends, we shall scarcely ascribe much weight to what is probably a mere coincidence. It so happens that the towns and cities

supplied with soft water—such as Glasgow, Manchester, Leeds, Huddersfield, Halifax—are chiefly manufacturing centres whose inhabitants are liable to suffer from overcrowding, from unhealthy and hazardous employments, and from a polluted atmosphere.

As regards industrial uses, soft water is also generally preferable. For brewing, indeed, the reverse holds good; but it is very easy for brewers to procure their supply of hard water by sinking deep wells. Prof. Ansted, indeed, remarks that "dyeing, bleaching, paper-making, and some kinds of chemical manufactures require the absence of certain ingredients occasionally present in natural water, but none of these manufactures either need or could obtain chemically pure water. Some are much easier and better carried on by water containing much organic impurity." To the ideas expressed in this passage exception must be taken. As a rule chemical manufactures and tinctorial operations succeed better the purer is the water employed. There are certain exceptional cases, such as what was formerly called "madder-work," where the presence of bicarbonate of lime in the water is essential. In dyeing so-called "sad colours" salts of lime and magnesia are also useful as economising dye-wares. But in the majority of cases the dyer, tissue-printer, and bleacher would use chemically pure water were it to be had. Elsewhere Prof. Ansted informs us that "a manufacturer at St. Denis found that for wool-washing muddy and infected water from the Groult was greatly superior to the clear water of an Artesian well." At this statement we are by no means surprised; the water from the Artesian well would assuredly be hard, and therefore unfit for washing, whilst the impurities of the river—if of an excrementitious nature—would have a directly detergent effect upon the wool. Finally, we must remember that it is much easier to harden a soft water, if such hardness is required for any special purpose, than to soften a hard one.

Let us now turn to the last consideration—the selection of the hands in which the water-supply of a town is to be vested. Mr. Bateman is an advocate for everything on which the material prosperity of a town depends—such as police, sewerage, water-supply—being in the hands of the inhabitants themselves, and all, we believe, save those who are directly or indirectly interested in the prosperity of water-companies, will cordially support this view. We have the greatest respect for private enterprise whenever and wherever it is kept in due order by the presence, or at least

by the possibility, of competition. But we cannot trust it a hair's breadth further. Give an individual, or, what is still worse, a company, a perpetual and indefeasible monopoly, and a career of extortion and of the most high-handed official insolence is at once inaugurated. Of all such monopolies that of a water-company is the worst, because, save by removal from the district, there is no escape from its power. If a gas-company overcharges us or supplies a wretched article we can take refuge in lamps, or in the electric light, or even make our own gas, as is done in many large establishments in the North of England. But for water we can find no substitute. Mr. Shirley Hibberd* proposes, indeed, that the water should be collected on the house-tops, filtered, and kept not in cisterns exposed to air and light, but in underground tanks, lined of course with impervious materials. From a sanitary point of view the plan is feasible, and were it carried out would materially weaken the grasp of those eight old men of the water who are riding about in triumph upon the shoulders of London. But it has one fatal fault; neither landlords nor tenants will consent to the heavy first outlay. Hence we fear that no appreciable relief to the public can be obtained by this method. As for the metropolitan wells they have long since been condemned as suspicious. Seeing, therefore, that London is and must be solely dependent upon water-supplies drawn from without its ever-widening limits, we shall the better appreciate the wisdom of the legislature in granting to the water-companies a perpetual monopoly. Why such and similar companies should be thus exceptionally favoured we know not. The rights of a patentee lapse at the end of his term of fourteen years. A lessee, at the expiration of his lease, sees the land he has held and the buildings he has erected become the property of the lessor. Water-companies, if sanctioned at all, should have been dealt with in a similar manner. In France they receive a concession for one hundred years, after which their privileges, and even their reservoirs, mains, and other property, revert to the public authorities.

What water-companies will do and what Parliament will sanction may be learnt from the case of Sheffield. When the bursting of the great Bradfield reservoir had drowned more than one hundred people, and destroyed or damaged property exceeding in value the total assets of the local

* Water for Nothing: Every House its Own Water-Supply. By SHIRLEY HIBBERD, F.R.H.S. London: Effingham Wilson.

Water Company, they asked for and obtained permission to borrow a sum sufficient to cover the damages, and to raise their charges for water, so as to pay the interest of the loan and gradually to refund the principal. Thus the people of Sheffield were taxed for the destruction of their own property! This is in principle the same as if the well-known Glasgow Bank had received power to borrow a sum sufficient to cover all its liabilities and to recoup itself out of the pockets of its clients!

It must be remembered that the very fundamental purpose of water-works differs according as they are vested in a municipality or in a company. In the former case the object is to supply the town with the best and most abundant water at the lowest price, utilising the profits of the undertaking for the reduction of local taxation or for carrying out needed improvement. The aim of a water-company, on the contrary, is to make the largest possible profit out of the job of supplying water, its wholesomeness, quantity, &c., being of course very secondary considerations. Anything more iniquitous than the present method of charging for water, as pursued in London, can scarcely be imagined. Your landlord raises your rent, or a parish surveyor, proceeding upon principles fundamentally false,* values your house at a higher figure, and straightway the water-company—without giving you either more or better water—exacts a higher figure for the supply. Nay, we know instances where an increase of 20 per cent has been required without any pretext whatever. Surely such an event is of itself amply sufficient to ensure the condemnation of the water-companies. But these monopolist bodies make themselves further notorious by their opposition to every improvement. They are not willing to introduce the constant system; they dislike water-meters; they shrink, in too many instances, from a thorough filtration of their water or from softening it by the Clark process. Or if they make any of these concessions to modern public opinion it is used as a basis for further extortion.

On the contrary, if we wish to see a satisfactory water-supply, we must look to those cities and towns where it is administered by municipalities.

If we next use our four conditions as a standard for testing the water-arrangements of London, we shall find

* That shops, *e.g.*, in the suburbs of London should be valued more highly in proportion as the neighbourhood grows more populous is intelligible. But why a dwelling-house should be rated at a heavier sum when dirt, noise, and traffic increase, and the wealthier inhabitants move away, is an enigma.

them defective in every particular. In the first place, the quantity of water available under present arrangements is not largely in excess of the probable future demand. The daily consumption has grown from 95 million gallons daily in 1869 to 146 million gallons during the summer of 1878. As Mr. Bateman remarks, "there is no adequate source within the means of any of the existing companies to which they can resort" for the needful increase of the available supply. "They will hardly be permitted to increase the draught from the Thames, and any supplies which could still be obtained from the chalk basin on which London lies are altogether insufficient to meet future demands."

That the London water-supply is not continuous, but intermittent, we all know, many of us to our cost. It is not, however, sufficiently known that the city of Manchester, since it adopted a continuous water-supply at high pressure, has not only been able to dispense with fire-engines, but to make a reduction in the property destroyed by fire of 14·3 per cent.*

As to the quality of the London water-supply, the facts furnished by Prof. Frankland and published by the Registrar-General ought to be sufficient. Two companies indeed furnish a water tolerably free from organic impurities, but in return most unpleasantly hard and grossly unfit for washing and cooking.

It may be asked why London has been so long content with the old order of things, and has patiently borne the heavy yoke of the companies? The answer must be sought for in its want of municipal unity. The desultory action of individual "parishes" was utterly unable to cope with the gigantic monopolies which have to be encountered. As far back as 1869 the Duke of Richmond's Commission reported "that the general control of the water-supply should be entrusted to a responsible public body." But no such body has hitherto been constituted.

As to the possible sources of a better and more abundant water-supply there is nothing at all adequate to be found in the south-east of England. The water of the Bagshot Sands is unsurpassed in quality, but its quantity is totally insignificant. The scheme propounded by the Metropolitan Board of Works, and introduced into Parliament in 1878, would have merely furnished 16 million gallons daily,—say

* During the past year there were 60 cases of fire in the metropolis in which, says Captain Shaw, "the water arrangements were unsatisfactory." In the majority of cases the "unsatisfactory arrangements" consisted in the absence or late arrival of the turncock.

about one-twentieth part of what will be needed,—at a first cost of five and a half millions. It has been said that the Thames is the "natural" water-supply of London. Granting that this may be true in a certain sense, we have already drawn upon the Thames too heavily. If we make further demands we shall seriously interfere with the navigation above London during average summers. But further, when we have done our utmost towards the exclusion of sewage, the waters of a navigable river flowing through a populous and cultivated country can never be fit for domestic uses.

One outlet remains at present. As was pointed out by Mr. Bateman as far back as 1865, the head-waters of the Severn are capable of yielding a supply of 220 million gallons daily, unsurpassed for purity and softness, and not likely to be polluted by industrial operations or the increase of local population. This source may, however, soon be unavailable, Liverpool having turned its eyes in the same direction. To bring 200 million gallons daily to London would cost £10,850,000. This is certainly a very serious sum. But we learn that the Corporation of Manchester do not hesitate to spend £3,425,000 over bringing an additional supply of 50 million gallons daily from Thirlmere—a heavier outlay in proportion to the resources of the northern city.

The greatest difficulty in the case of the metropolis springs from the so-called "vested interests" of the eight water-companies. To buy these bodies out for a sum down would of course be a most costly undertaking. Mr. Bateman proposes to take over their works, reservoirs, mains, and privileges, guaranteeing them the same dividends as they are now receiving, secured as a first charge on the municipal water-rate. Even with this burden it appears that the burdens of the rate-payers of London would not be increased.

But there is, or at least may be, a third alternative possible. If a perpetual monopoly of the right of supplying water to the metropolis has been formally and explicitly ensured to the companies, then—iniquitous as was the transaction—it must be strictly carried out. If, however, no such stipulation has been made, then no considerations of a romantic or sentimental nature ought to be admitted. Let the new Board be constituted, carry out Mr. Bateman's or some other approved scheme, and begin supplying water in opposition to the companies: they will soon be compelled to give up the contest, and will be glad to sell their reservoirs and feeding-grounds on easy terms.

II. THE FORMATION OF COAL.

By W. Mattieu Williams, F.R.A.S., F.C.S.

IN the course of a pedestrian excursion made in the summer of 1855 I came upon the Aachensee, one of the lakes of North Tyrol rarely visited by tourists. It is situated about 30 miles N.E. of Innspruck, and fills the basin of a deep valley, the upper slopes of which are steep and richly wooded. The water of this lake is remarkably transparent and colourless. With one exception, that of the Fountain of Cyane,—a deep pool forming the source of the little Syracusan river—it is the most transparent body of water I remember to have seen. This transparency revealed a very remarkable sub-aqueous landscape. The bottom of the lake is strewn with branches and trunks of trees, which in some parts are in almost forest-like profusion. Being alone in a rather solitary region, and carrying only a satchel of luggage, my only means of further exploration were those afforded by swimming and diving. Being an expert in these, and the July summer day very calm and hot, I remained a long time in the water, and, by swimming very carefully to avoid ripples, was able to survey a considerable area of the interesting scene below.

The fact which struck me the most forcibly, and at first appeared surprising, was the upright position of many of the large trunks, which are of various lengths—some altogether stripped of branches, others with only a few of the larger branches remaining. The roots of all these are more or less buried, and they present the appearance of having grown where they stand. Other trunks were leaning at various angles and partly buried, some trunks and many branches lying down.

On diving I found the bottom to consist of a loamy powder of grey colour, speckled with black particles of vegetable matter—thin scaly fragments of bark and leaves. I brought up several twigs and small branches, and with considerable difficulty, after a succession of immersions, succeeded in raising a branch about as thick as my arm and about 8 feet long, above three-fourths of which was buried, and only the end above ground in the water. My object was to examine the condition of the buried and immersed wood, and I selected this as the oldest piece I could reach.

I found the wood very dark, the bark entirely gone, and

the annual layers curiously loosened and separable from each other, like successive rings of bark. This continued till I had stripped the stick to about half of its original thickness, when it became too compact to yield to further stripping.

This structure apparently results from the easy decomposition of the remains of the original cambium of each year, and may explain the curious fact that so many specimens of fossilised wood exhibit the original structure of the stem, although all the vegetable matter has been displaced by mineral substances. If this stem had been immersed in water capable of precipitating or depositing mineral matter in very small interstices, the deposit would have filled up the vacant spaces between these rings of wood as the slow decomposition of the vegetable matter proceeded. At a later period, as the more compact wood became decomposed, it would be replaced by a further deposit, and thus concentric strata would be formed, presenting a mimic counterpart of the vegetable structure.

The stick examined appeared to be a branch of oak, and was so fully saturated with water that it sunk rapidly upon being released.

On looking around, the origin of this sub-aqueous forest was obvious enough. Here and there the steep wooded slopes above the lake were broken by long alleys or downward strips of denuded ground, where storm-torrents or some such agency had cleared away the trees and swept most of them into the lake. A few uprooted trees lying at the sides of these bare alleys told the story plainly enough. Most of these had a considerable quantity of earth and stones adhering to their roots: this explains the upright position of the trees in the lake.

Such trees falling into water of sufficient depth to enable them to turn over would sink root downwards, or float in an upright position, according to the quantity of adhering soil. The difference of depth would tend to a more rapid penetration of water in the lower parts, where the pressure would be greatest, and thus the upright or oblique position of many of the floating trunks would be maintained till they absorbed sufficient water to sink altogether.

It is generally assumed that fossil trees which are found in an upright position have grown on the spot where they are found. The facts I have stated show that this inference is by no means necessary, not even when the roots are attached and some soil is found among them. In order to account for the other surroundings of these fossil trees a very violent hypothesis is commonly made, viz., that the

soil on which they grew sunk down some hundreds of feet without disturbing them. This demands a great strain upon the scientific imagination, even in reference to the few cases where the trees stand perpendicular. As the majority slope considerably the difficulty is still greater. I shall presently show how trees like those immersed in Aachensee may have become, and are now becoming, imbedded in rocks similar to those of the Coal Measures.

In the course of subsequent excursions on the fjords of Norway I was reminded of the sub-aqueous forest of the Aachensee, not by again seeing such a deposit under water, for none of the fjords approach the singular transparency of this lake, but by a repetition on a far larger scale of the downward strips of denuded forest ground. Here, in Norway, their magnitude justifies me in describing them as vegetable avalanches. They may be seen on the Sogne fjord, and especially on those terminal branches of this great estuary, of which the steep slopes are well wooded. But the most remarkable display that I have seen was in the course of the magnificent, and now easily made, journey up the Storfjord and its extension and branches, the Slyngsfjord, Sunelvsfjord, Nordalsfjord, and Geirangerfjord. Here these avalanches of trees, with their accompaniment of fragments of rock, are of such frequent occurrence that sites of the farmhouses are commonly selected with reference to possible shelter from their ravages. In spite of this they do not always escape. In the October previous to my last visit a boathouse and boat were swept away; and one of the recent tracks that I saw reached within twenty yards of some farm buildings.

What has become of the millions of trees that are thus falling, and have fallen, into the Norwegian fjords during the whole of the present geological era? In considering this question we must remember that the mountain slopes forming the banks of these fjords continue downwards under the waters of the fjords which reach to depths that in some parts are to be counted in thousands of feet.

It is evident that the loose stony and earthy matter that accompanies the trees will speedily sink to the bottom and rest at the foot of the slope somewhat like an ordinary sub-aërial talus, but not so the trees. The impetus of their fall must launch them afloat and impel them towards the middle of the estuary, where they will be spread about and continue floating, until by saturation they become dense enough to sink. They will thus be pretty evenly distributed over the bottom. At the middle part of the estuary they will

form an almost purely vegetable deposit, mingled only with the very small portion of mineral matter that is held in suspension in the apparently clear water. This mineral matter must be distributed among the vegetable matter in the form of impalpable particles having a chemical composition similar to that of the rocks around. Near the shores, a compound deposit must be formed consisting of trees and fragments of leaves, twigs, and other vegetable matter mixed with larger proportions of the mineral *débris*.

If we look a little further at what is taking place in the fjords of Norway we shall see how this vegetable deposit will ultimately become succeeded by an overlying mineral deposit which must ultimately constitute a stratified rock.

All these fjords branch up into inland valleys down which pours a brawling torrent or a river of some magnitude. These are more or less turbid with glacier mud or other detritus, and great deposits of this material have already accumulated in such quantity as to constitute characteristic modern geological formations bearing the specific Norsk name of *ören*, as *Laerdalsören*, *Sundalsören*, &c., describing the small delta plains at the mouth of a river where it enters the termination of the fjord, and which from their exceptional fertility constitute small agricultural settlements bearing these names, which signify the river sands of *Laerdal*, *Sundal*, &c. These deposits stretch out into the fjord, forming extensive shallows that are steadily growing and advancing further into the fjord. One of the most remarkable examples of such deposits is that brought by the Storelv (or Justedals Elv), which flows down the Justedal, receiving the outpour from its glaciers, and terminating at Marifjören. When bathing here I found an extensive subaqueous plain stretching fairly across that branch of the Lyster fjord into which the Storelv flows. The waters of the fjord are whitened to a distance of two or three miles beyond the mouth of the river. These deposits must, if the present conditions last long enough, finally extend to the body, and even to the mouth of the fjords, and thus cover the whole of the bottom vegetable bed with a stratified rock in which will be entombed, and there be well preserved, specimens of the trees and other vegetable forms corresponding to those below, which have been lying so long in the clear waters that they have become soddened into homogeneous vegetable pulp or mud, only requiring the pressure of solid superstratum to convert them into coal.

The specimens in the upper rock, I need scarcely add, would be derived from the same drifting as that which pro-

duced the lower pulp; but these coming into the water at the period of its turbidity and of the rapid deposition of mineral matter, would be sealed up one by one as the mineral particles surrounding it subdivided. Fossils of estuarine animals would of course accompany these, or of fresh-water animals where, instead of a fjord, the scene of these proceedings is an inland lake. In reference to this I may state that at the inner extremities of the larger Norwegian fjords the salinity of the water is so slight that it is imperceptible to taste. I have freely quenched my thirst with the water of the Sörfjord, the great inner branch of the Hardanger, where pallid specimens of bladder wrack were growing on its banks.

In the foregoing matter-of-fact picture of what is proceeding on a small scale in the Aachensee, and on a larger in Norway, we have, I think, a natural history of the formation not only of coal seams, but also of the coal measures around and above them. The theory which attributed our coal seams to such vegetable accumulations as the rafts of the Mississippi is now generally abandoned, mainly because it fails to account for the state of preservation and the position of many of the vegetable remains associated with coal, which show no signs of river transport.

There is another serious objection to this theory that I have not seen expressed. It is this:—Rivers bringing down to their mouths such vegetable deltas as are supposed, would also bring considerable quantities of earthy matter in suspension, and this would be deposited with the trees. Instead of the 2 or 3 per cent of incombustible ash commonly found in coal we should thus have a quantity more nearly like that found in bituminous shales, viz., from 20 to 80 per cent.

The alternative hypothesis now more commonly accepted —that the vegetation of our coal-fields actually grew where we find it—is also refuted by the composition of coal-ash. If the coal consisted simply of the vegetable matter of buried forests its composition should correspond to that of the ashes of plants; and if so the refuse from our furnaces and fireplaces would be a most valuable manure. This we know is not the case. Ordinary coal-ash, as Bischof has shown, nearly corresponds to that of the rocks with which it is associated; and he says that "the conversion of vegetable substances into coal has been effected by the agency of water;" and also that coal has been formed, not from dwarfish mosses, sedges, and other plants which now contribute to the growth of our peat bogs, but from the stems and trunks of the forest trees of the Carboniferous Period,

such as *Sigillariæ*, *Lepidodendra*, and *Coniferæ*.* All we know of these plants teaches us that they could not grow in a merely vegetable soil containing but 2 or 3 per cent of mineral matter. Such must have been their soil for hundreds of generations in order to give a depth sufficient for the formation of the South Staffordshire 10 yard seam.

All these and other difficulties that have stood so long in the way of a satisfactory explanation of the origin of coal appear to me to be removed if we suppose that during the Carboniferous Period Britain and other coal-bearing countries had a configuration similar to that which now exists in Norway, viz., inland valleys terminating in marine estuaries, together with inland lake basins. If to this we superadd the warm and humid climate usually attributed to the Carboniferous Period, on the testimony of its vegetable fossils, all the conditions requisite for producing the characteristic deposits of the Coal Measures are fulfilled.

We have first the under-clay due to the beginning of this state of things, during which the hill slopes were slowly acquiring the first germs of subsequent forest life, and were nursing them in their scanty youth. The deposit, then, would be mineral mud with a few fossils and that fragmentary or fine deposit of vegetable matter that darkens the carboniferous shales and stripes the sandstones. These characteristic striped rocks—the "linstey" or "linsey" of the Welsh colliers—is just such as I found in the course of formation in the Aachensee near the shore, as described above.

The prevalence of estuarine and lacustrine fossils in the Coal Measures is also in accordance with this: the constitution of coal-ash is perfectly so. Its extreme softness and fineness of structure; its chemical resemblance to the rocks around, and above, and below; the oblong basin form common to our coal seams; the apparent contradiction of such total destruction of vegetable structure common to the true coal seams, while immediately above and below them are delicate structures well preserved, is explained by the more rapid deposition of the latter, and the slow soddening of the former as above described.

I do not, however, offer this as an explanation of the formation of *every kind of coal*. On the contrary, I am satisfied that cannel coal, and the black shales usually associated with it, have a different origin from that of the ordinary varieties of bituminous coal. The fact that the products of distilla-

* Hull, On the Coal-fields of Great Britain.

tion of cannel and these shales form different series of hydrocarbons from those of common coal, and that they are nearly identical with those obtained by the distillation of peat, is suggestive of origin in peat-bogs, or something analogous to them.

III. LIVING HONEYCOMB: A NOVEL PHASE OF ANT LIFE.*

MUCH as has been written about the marvels of instinct, there are still discoveries of great interest to be made in this prolific field. Particularly in the domain of those insect Yankees, the ants, with their wonderful ingenuity and human-like manners and customs, there is room for extended observations.

Some lately-discovered facts in relation to them are so curious and interesting that it may be advisable to give them greater publicity than they have yet obtained. Some of these facts have long been known to the world of Science, but not to the public. Others are new discoveries. As a whole they form one of the most surprising chapters in the history of animal life and contrivance.

Varied as are the social habits of the ants, it is generally considered that social bees surpass them in one particular, namely, their mode of storing supplies of winter food, the storehouses of ant-food having no contrivance similar in ingenuity to the honeycomb, with its rich supply of the sweets of life.

But the truth is that certain tribes of ants are well aware of the value of nature's sweetmeats as articles of food, and have developed a mode of storing up their winter honey still more curious than that practised by the bees. They possess, in fact, what may be called living honeycombs; perambulatory cells filled with distilled sweetness. We refer to the honey-bearing ants of New Mexico, concerning which some very interesting facts have been brought to light during the past summer.

The Rev. Dr. M'Cook, of Philadelphia, a noted observer of ants and ant-life, has been interviewing these honey-bearers, and his results differ so widely from the ordinary facts of insect instinct that they cannot but prove of general interest. These ants had been previously known only in

* This account of Dr. M'Cook's results has been kindly communicated to the Editor by Mr. C. Morris, Philadelphia.

New Mexico, but he discovered them in Colorado, inhabiting the locality known as the "Garden of the Gods," their nests being excavated in the stony crests of low ridges which run through this mountain-girt Paradise.

The ridges are composed of a friable sandstone, into which our minute masons mine deeply, digging galleries which sometimes run for several feet into the rock. The nest, outwardly, is some 10 inches in diameter by from 2 to 3½ inches in height, composed of sand and bits of stone carried from within, some of which seem large enough to defy a regiment of ants to move them.

Inside the nests successive chambers are excavated, connected by galleries, the floors of the chambers being comparatively smooth, while the ceilings are left in a rough state. But this roughness is no evidence of carelessness in the builder. It has, on the contrary, an important object: this is to furnish foothold for the clinging feet of certain extraordinary-looking creatures, which form the living honeycombs of which we have spoken.

Fancy an animal with the head and thorax of a small ant, but with all the posterior portion of the body converted into a round sac, of the size of a large pea, and of a rich translucent amber hue,—it being, in fact, distended into a reservoir of honey. This honey-bag is immense when compared with the size of the ant, the unchanged parts of which might pass for a black pin's head attached to the side of a marrowfat pea. These odd-looking creatures cling to the roof of the chamber with their feet, the distended honey-bag hanging downwards like an amber globe. On seeing them we instinctively imagine that their leg-muscles must be developed in a fashion to put to shame those of human athletes, since it is no light weight which they are thus forced to continuously support.

In each chamber of the nest about thirty honey-bearers are found, making some three hundred to the complete nest. Besides these there are hundreds or thousands of others, workers and soldiers, lords and queens, to whom the honey-bearers serve as storehouses of winter food.

Dr. M'Cook succeeded in bringing some of these home with him alive, providing them with nest-building materials, and with sugar for nutriment. He has one very interesting nest in a glass bottle, with its interior chamber well displayed. The roof of this is covered with depending globules of honey, so large as almost to conceal the minute clinging insect of which they really form part.

But the marvellous feature of the case yet remains to be

described. Not only is the abdomen of the ant converted into a receptacle for honey, but the whole internal economy of the body is transformed for this purpose. All the organs of the abdomen have quite disappeared: viscera, nerves, veins, arteries, have alike vanished; and there remains only a thin transparent skin, which is capable of great distension. It is thus in reality a honey-cell, and much stranger than that of the bee, the waxen walls of the latter being replaced in this case by the tissues of a living animal. The creature can afford to dispense with the abdominal organs, since its life-duties are so metamorphosed that it has henceforth to act only as an animated sweetmeat.

Dr. M'Cook's observations enabled him to discover that the working ants, returning from their out-door foraging, with their bodies distended with the honey they have somewhere harvested, enter the chambers of the nest and eject this sweet fluid from their own mouths into the mouths of the honey-bearers, whose bodies become greatly distended with the delicious food. In other cases he perceived hungry ants seeking for a meal from the food thus generously stored up. The honey-bearer seemed to slightly contract the muscles of the abdominal skin, forcing from its mouth minute globules of honey: these clung to the hairs of the under lip, and were eagerly lapped up by the hungry ants waiting to be fed. It is probable, however, that these supplies are principally intended as winter-stores for the workers, for the feeding of the larvæ, and for the dinner-table of the queen, who is, as usual, too proud or too dignified to do her own foraging.

The working ants take great care of their helpless honey-bearers. When one, through some convulsion of Nature,—occasioned perhaps by the tap of a gigantic human finger,—looses its hold, and drops to the floor of its chamber, it is at once picked up by a worker, and carried back to its old foothold on the roof of the apartment. How this minute creature can drag up a perpendicular wall a mass twenty times its own size and weight is only less surprising than it would be to see an adroit climber of the human race ascending the face of a precipice and pulling after him a ton weight.

With regard to the source of the honey, these ants are not known to feast on flowers, like bees and some of our home ants, nor could any evidence be found of the presence of the *Aphis*, or ant-cow, which many of our ants milk for its honey.

The honey-gatherer is difficult to observe. It is a nocturnal ant, keeping out of sight of the sun during the day, and only venturing forth at nightfall in search of food. Dr. M'Cook observed them, in the summer twilight, marching outward from the nest in long columns, and pursuing night after night the same paths. He watched them for a considerable time before he succeeded in finding the goal of these nightly expeditions. At length, discovering some ants on the twigs of a species of scrub oak, which grew abundantly at the foot of the ridge, he observed that they showed a marked preference for certain small oak-galls which were ranged along the sides of the twigs.

The next thing to be done was to examine these galls. We are accustomed to associate galls with the idea of bitterness only, yet they proved to be the true honey-yielders. On the round green masses minute drops of a sweet juice were found: this the ants eagerly licked up, passing from gall to gall until fully laden, or returning to the original gall at a later hour when fresh sweetness had exuded from it.

The gall-nut, it is well known, is an excrescence upon the leaves of a species of oak; it is produced by the puncture of a small hymenopterous insect for the purpose of depositing its eggs. A minute grub lies in the centre of the soft mass which composes the gall. Whether the sweet juice came from this grub, or from the sap of the tree, was not readily to be discovered, though it was most likely an exudation of the sap.

All night the busy gatherers of sweets were occupied in collecting honey from the galls. Towards morning they were seen in great numbers returning to the nest, their bodies swollen with the night's harvest of honey, which, as we have said, is given to the living honeycombs within, being forced from the bodies of the workers and into the mouths of the honey-bearers, until, by the time the season is over, they present a remarkable distension.

This is about all that is known at present concerning the habits of these strange ants. They very likely have other sources of honey at other seasons; but the most interesting fact is the surprising mode of storage of this sweet food.

In New Mexico the inhabitants put these ants to a very peculiar use, supplementing their dinners with a plateful of honey ants for dessert. The overladen insects wait in enforced patience while the preceding courses of the dinner

are being eaten. The mode of partaking of this strange dessert is to pick up an ant, nip the honey-bag with the teeth, forcing its sweet contents into the mouth, while the remainder is thrown away. We are told that this is not so disagreeable a habit as it might at first sight seem, the skin surrounding the honey being reduced to a thin transparent membrane, with nothing necessarily unpleasant in its character. Nevertheless, most of us will prefer to continue indebted to the bee for our supply of honey, leaving the ants to enjoy the fruits of their own labours.

IV. EDMUND HALLEY: HIS LIFE AND WORK.

ON June 12th, 1874, Prof. Adams, President of the Royal Astronomical Society called the attention of the members at the meeting to the original labours of Jeremiah Horrocks in connection with the then forthcoming transit of Venus; the result being the erection of a memorial to Horrocks in Westminster Abbey. Several of those who took then such a keen interest in the noblest of astronomical problems (one of whose keys was about to be unlocked by the keen observers of various nationalities) have passed away; but the veterans who survive, together with an ever-increasing crowd of junior recruits, are now looking forward to the next recurrence of the infrequent transit, and on this occasion we may well devote a page to an outline of the life of the famous Dr. Halley, whose name is so well known, but whose history has yet to be written. For beyond more or less unsatisfactory and inauthentic sketches of his career, no actual scientific biography of our grand countryman exists. The want of such a work will, we believe, be ere long supplied by the Savilian Professor of Astronomy at Oxford, in whose hands the mass of material collected by the late Prof. Rigaud rests; so that the result of the editorial labours of the Reverend Professor Pritchard may be looked

for at an early date. Meantime we may briefly recapitulate what is generally known of the indefatigable and long-lived cosmographer to whom it is now proposed to erect a fitting monument on the site of his deserted station at St. Helena.

Edmund Halley was born at Haggerston, near London, on the 29th of October, 1656, and was the only son of a soap-boiler. He was educated at St. Paul's School, and at an early age evinced a peculiar aptitude for mathematics. He first applied himself to the study of languages and sciences, and at sixteen years of age made original observations on the movements of the magnetic needle before he left St. Paul's School. In 1673 his university career commenced at Queen's College, Oxford, where, at the age of twenty, he made careful observations of the spots on the sun, the first results of his study of solar physics, made during July and August, 1676, being published in conjunction with those of Flamsteed.

Young Halley's first ambitious scheme was to make an accurate general catalogue of the stars, and as Hevelius and Flamsteed were employed in cataloguing the stars of the Northern Hemisphere, interest was made with the then reigning monarch, Charles II. (who appears to have been much interested with the ardent enthusiasm of the young astronomer), who permitted Halley to proceed, *at his own expense*, to the nearest available spot under the southern tropic, viz., St. Helena, which small island had been retaken by Sir Richard Munden from the Dutch in 1673, and re-granted to the East India Company by a new charter, and a European garrison was raised for its defence under Captain Gregory Field. The educational state of the island in those days may be judged from the fact that three of the few members of Council were unable to write, and could only affix their marks to the proceedings of the Board. The latitude and longitude of the island even were imperfectly known, and the means of ascertaining the latter were so inaccurate on board ship that at least one ship returned to England with the intelligence that the island had disappeared altogether. Halley's journal or log-book of the voyage is still extant, and what is now a matter of a fortnight's steaming in a Union Company or Donald Currie steamer was then a formidable voyage of two or more months (the *Northumberland*, under Rear-Admiral Sir George Cockburn, leaving the Start on the 9th of August, reached St. Helena on the 15th of October, 1815, with Napoleon on board), and we can imagine the enjoyment he must have felt during the tropical nights on the Atlantic, and the first indelible impressions

with which he beheld the gradual rising of the Centaur, Argo, Crux, and the Nubeculæ of Magellan, whose pale phosphorescent radiance contrasts with the dark spot through which the terrestrial spectator catches a glimpse of the ultra-planetary depths of space.

Arrived in St. Helena, then overgrown with forests and rare shrubs, now extinct for ever, he appears to have landed at James's Fort, in Chapel Valley, late in the year, and must have found no small difficulty in the selection of a site for his temporary observatory; but doubtless tempted by the unusual clearness of the season, he selected a magnificent situation on the northern side of the central mountain, to which he must have had considerable difficulty in transporting his instruments, as even with the present modern roads wheeled transport is most limited and precarious. Under Governor Field, however, with slave labour and royal auspices, Halley industriously set to work towards the completion of the catalogue of the southern stars, and delineated a planisphere of their projection. It was here, says Prof. Forbes, that "Halley was the first to see clearly what a powerful means of determining the sun's parallax an observation of contact really is. So far as I can discover, he first mentions the method in a letter to Sir Jonas Moore, written at St. Helena in 1677,* just after having seen a transit of Mercury. The exactness with which he believed the time of contact to be determinable led him frequently afterwards to urge his countrymen to make every effort to utilise the method on the occasion of the transits of 1761 and 1769, when he should be dead.† And thus, in addition to his celebrated prediction of a comet, he left a second legacy to his successors, who, as Englishmen, might be entitled to be proud of his foresight, though he could not live to reap the glory of it."—("The Coming Transit of Venus," by Prof. George Forbes, "Nature," April 23, 1874.

"Halley saw (what many people fail to see even now) that the great accuracy of the method consists in this, that in one second of time Venus moves over about 0·02″; and if we can determine the time of contact, with an error of no more than a second, we are measuring the sun's parallax with an error of no more than 0·02 of a second of arc. Halley even pointed out the best stations for observations."—(*Ibid.*)

Ninety-four years subsequently to this letter Dr. Maskelyne

* Hooke's Lectures and Collections. 1678.

† Catalogus Stellarum Australium; also Phil. Trans., 1694 and 1715.

and Mr. Waddington were able to take advantage of Halley's legacy, and to partake in their share of its fruition.

The result of Halley's observations in the Southern Hemisphere, made in spite of the clouds which hung over the heights of the rocky island (caused by the counter-current of air above the trade-winds), was the publication of the positions of 350 stars which he had fixed in his "Catalogus Stellarum Australium." (See Humboldt's "Cosmos," vol. iii., 207.)

Halley returned to England in 1678, and at the early age of 22 years was elected a member of the Royal Society. On his return to England he was not idle, for we soon find him at Dantzic engaged in settling a friendly and international controversy between the Royal Astronomer of England and Dr. Hevelius. He was travelling on the Continent with his companion Mr. Nelson when—between Calais and Paris—he made his second (December) observations of the remarkable direct elliptic comet of 1680, the length of whose tail was calculated at 100 millions of miles, with a period of 8813 years, having observed it before its perihelion passage the previous month.

During a portion of 1681 Halley spent a considerable time in Paris with Cassini at the Observatory, and subsequently went to Italy, where we find a record of him in a first edition of a copy of the "Principia" of his friend Newton, bearing an autograph inscription from the donor to the Abbé Nazari, who edited a scientific journal at Rome at this period. The following is the entry in Halley's handwriting* :—

ILLUSTRISSIMO DNO
DRO ABBATI NAZARIO
ROMÆ HUMILLIME OFFERT
EDM. HALLEY.

During the year 1682 Halley observed and determined the parabolic elements of the retrograde orbit of the remarkable comet of long period which bears his name. The results of his calculations made it evident to him that this comet must have been identical with the comet observed in 1607 by Kepler and Longomontanus, and also with one whose elements were calculated from observations by Apian, at Ingoldstadt, in 1531, and which previously appeared in 1456 and 1378, as calculated by Pingré and Langrier. Halley predicted the return of this comet at the close of 1758 or

* See Nature, March 6, 1879, p. 422.

beginning of 1759—the first prediction of the return of a comet.

This comet, as is well known, actually passed its perihelion on March 12th, 1759, just one month before the time calculated by Clairaut, Lalande, and Madame Lepaute; and again on November 15.95, 1835, within five days of Rosenberger's elaborate calculation. We now await the next advent of Halley's comet in 1909-10, its perihelion passage being fixed by the late Count G. de Pontécoulant (as communicated by him to the Paris Academy of Sciences in 1864) to May 23.87 (Paris time?), 1910; it having been last glimpsed by Dr. Lamont with the Munich refractor on May 17th, 1836. (See "Nature," February 11, 1875, p. 286.)

An account of his next research is given by K., in a paper on the "Early History of Magnetism," in "Nature," April 27, 1876, p. 523, as follows:—"In 1683 Halley presented a paper of great importance to the Royal Society of London, entitled 'A Theory of the Variation of the Magnetical Compass.' In this communication he states that the 'deflection of the magnetical needle from the true meridian is of that great concernment in the art of navigation that the neglect thereof does little less than render useless one of the noblest inventions mankind ever yet attained to,' and gives as the result of 'many close thoughts' the following explanation of the variation of the compass:—

"'The whole globe of the earth is one great magnet, having four magnetical poles or points of attraction, near each pole of the equator two; and in those parts of the world which lie near adjacent to any one of those magnetical poles, the needle is governed thereby, the nearest pole being always predominant over the more remote.' He remarks that the positions of these poles cannot as yet be exactly determined, from want of sufficient data, but conjectures that the magnetic pole which principally governs the variations in Europe, Tartary, and the North Sea is about 7° from the North Pole of the earth, and in the meridian of the Land's End; whilst the magnetic pole which influences the needle in North America, and in the Atlantic and Pacific Oceans, from the Azores westward to Japan, is 15° from the North Pole, and in a meridian passing through the middle of California. The variation in the South of Africa, in Arabia, Persia, India, and from the Cape of Good Hope over the Indian Ocean to the middle of the South Pacific, is ruled by the most powerful of all these magnetic poles, which is situated 20° from the South Pole of the earth, and in a meridian passing through the island of

Celebes; in the remainder of the South Pacific Ocean, in South America, and the greater part of the South Atlantic Ocean, it is governed by a magnetic pole 16° from the South Pole in a meridian 20° west of the Straits of Magellan."

"On this hypothesis Halley explains the variation observed in different places, and among others cites the two following instances:—On the coast of America, about Virginia, New England, and Newfoundland, the variation was found to be west, being above 20° in Newfoundland, 30° in Hudson Strait, and 57° in Baffin's Bay. On the coast of Brazil, on the contrary, it was found to be east, being 12° at Cape Frio, and increasing to 20½° at the Rio de la Plata, thence decreasing towards the Straits of Magellan. Thus, almost in the same geographical meridian, we find the needle at one place pointing nearly 30° west, at another 20½° east: this is explained by the north end of the needle in Hudson Strait being chiefly attracted by the North American magnetic pole, whilst at the mouth of the Rio de la Plata the south end is attracted by the south magnetic pole situated west of the Straits of Magellan. Sailing north-west from St. Helena to the equator, the variation is always in the same direction, and slightly east. Here the South American is the chief governing pole, but its power is opposed by the attraction of the North American and Asian South Poles, the balance as you recede from the latter being maintained by approach to the former."

"During the next nine years Halley continued his investigation of the causes of magnetic variation, and in 1692 he made another communication to the Royal Society, in which he endeavoured to meet two difficulties he had always felt in his former explanation; one, that no magnet he had ever seen or heard of had more than two opposite poles; the other, that these poles were not—at least all of them—fixed in the earth, but slowly changed their positions. The following observations are cited by Halley in proof of the motion of the magnetic system:—At London, in 1580, the variation was 11° 15′ E., in 1622 it was 6° E., in 1634 it was 4° 5′ E., and in 1657 there was no variation; whilst in 1672 it was 2° 30′ W., and in 1692, 6° W. At Paris the variation was 8° or 9° E. in 1550, 3° E. in 1640, 0° in 1666, and 2° 30′ W. in 1681. At Cape Comorin it was 14° 20′ W. in 1620, 8° 48′ W. in 1680, and 7° 30′ W. in 1688. Halley considered the external parts of our earth as a shell, separated by a fluid medium from a nucleus or inner globe, which had its centre of gravity fixed and immovable in the common

centre of the earth, but which rotated round its axis a little slower than the superficial portions of the earth. The nucleus and the exterior shell he regarded as two distinct magnets, having magnetic poles not coincident with the geographical poles of the earth. The change observed in Hudson's Bay being much less than that observed in Europe, Halley concluded that the North American pole was fixed, while the European one was movable; and, from a similar observation on the coast of Java, he considered the Asian South Pole as fixed, and the pole west of the Straits of Magellan to be in motion. The fixed poles he regarded as those of the external shell, and the movable as those of the inner nucleus. Of these latter the one placed by him in the meridian of the Land's End was ascertained, in the present century, to have moved to Siberia in 120° E. long., and that placed by him 20° from the Straits of Magellan to have moved between 30° and 40° west of this position; while those poles regarded by Halley as fixed were found but slightly altered in position since his time. It is extremely interesting to find that not only modern observations of declination, but also those of dip and magnetic intensity, have received their best explanation on the assumption of four magnetic poles. Much, however, that is mysterious remains unsolved, and Halley's remarkable words may even now with truth be quoted:—"Whether these magnetical poles move altogether with one motion or with several, whether equally or unequally, whether circular or libratory, if circular about what centre, if libratory after what manner, are secrets as yet utterly unknown to mankind, and are reserved for the industry of future ages."—("K." *ibid.*)

Intent on still further carrying out his magnetic researches, Halley was successful in an application to King William to fit out a scientific expedition, and in 1698, as Capt. Halley, R.N., received his appointment to the command of H.M.S. *Paramour*, in which vessel, a Pink (?), his sailing orders directed him to seek by observations the discovery of the rule of variations of the compass, and as well to survey and lay down the latitude and longitude of His Majesty's American settlements. The *Paramour* left England in November, 1698, but was absent only for seven months, on account of sickness breaking out among the crew during their stay in the equatorial calms, and his Lieutenant mutinying. On their return home the Lieutenant was court-martialled and cashiered; and Capt. Halley, in no way disheartened, and with his expedition augmented by the presence of a smaller consort placed under him, set off in September, 1699, and

voyaged throughout the Atlantic Ocean from the Arctic to the Antarctic regions, until the ice stopped his progress. He revisited the well-known scenes of his early scientific success on the isolated rock of St. Helena, which doubtless inspired him with the thoughts of old Robert Herrick, whose lines aptly apply to this now barren spot:—

> "Rockie thou art, and rockie we discover
> Thy menne, and rockie are thy wayes all over.
> O menne! O manners! now, and ever knowne,
> To be a rockie generatione!
> A people currish, churlish as the seas,
> And rude almost, as rudest salvages;
> With whom I did, and may resojourne whenne
> Rocks turn to rivers, Rivers turn to menne."

The voyage of the *Paramour* included the coasts of the Brazils and the West Indies on the West, together with the West Coast of Africa, Madeira and the Canaries, &c., and lasted a whole year: the result was speedily made public by the production of the much-cited "Halley's Magnetic Chart" (on which the isogonal magnetic curves or "Halleian lines" were laid down), the original of which is in the British Museum. By the assistance of Mr. Winter Jones, the principal librarian, copies in a reduced size have been produced from this chart, and they were inserted as an Appendix in the Magnetical and Meteorological volume of the Astronomer Royal's Report at Greenwich for the year 1869.

In April, 1701, Capt. Halley was employed as Hydrographer to His Majesty, and surveyed the British Channel, an accurate chart of which was published under his superintendence, besides a systematic series of observations on the tides was undertaken with satisfactory conclusions. By this time the fame of Halley as astronomer, discoverer, and engineer, had spread throughout the civilised world, and the Emperor of Germany (Leopold), desirous of forming a harbour for shipping in the Adriatic, applied for and obtained from Queen Anne the services of Captain Halley, who embarked for Holland on November 22nd, 1702, and proceeded to Istria. In consequence of the political opposition of the Dutch, Halley's designs were not carried out as to the construction of two ports in Dalmatia; but the approval of the Emperor Leopold was signified by the present of a diamond ring and an especial letter of recommendation to the Queen of England, who again sent him to Istria, where, in conjunction with the Emperor's engineer, he added to the fortifications and harbour-works of Trieste. On this occasion, passing through Hanover, he supped with the Electoral

Prince (subsequently our King George I.) and his sister the Queen of Prussia, and at Vienna he was personally presented to the Emperor Leopold.

In 1703 Capt. Halley returned to his native country, and was made Professor of Geometry in the University of Oxford, in the place of Dr. Wallis, and the degree of LL.D. was also conferred upon him. The professorship of Astronomy at the University of Oxford was withheld from him, it is said, at the instigation of the orthodox Stillingfleet—another instance of the numerous attempts to stifle true scientific investigation by narrow-minded and bigoted divines.

The late Captain, now Doctor Halley, as indefatigable as ever, did not seek in his professorial chair the *otium cum dignitate:* only forty-seven years of age, he began to translate into Latin, from the Arabic, "Apollonius de Sectione Rationis," and to restore the two books "De Sectione Spatii" of the same author (which are lost), from the account given of them by Pappus; and he published the whole work in 1706. Afterwards he took a leading part in preparing for the press and editing "Apollonius' Conics," and he successfully supplied the whole of the eighth book, the original of which is lost. He likewise added Serenus on the Section of the Cylinder and Cone, printed from the original Greek, with a Latin translation, and published the whole in folio.

In 1713 he was made Secretary of the Royal Society, and on May 3rd, 1715, with the astronomer De Louville, he made his observations of the celebrated total solar eclipse from the house of the Royal Society, in Crane Court, Fleet Street, which he has so well recorded in the "Philosophical Transactions" of the Society.

In 1720 he was appointed Astronomer Royal at Greenwich, in room of his old friend and colleague Flamsteed; and nine years afterwards had the distinction of being chosen as a foreign member of the Academy of Sciences at Paris.

Full of years and honours this great man died at Greenwich, in his eighty-seventh year, after a long career of such scientific benefits to his countrymen as few of our greatest philosophic worthies can boast. Besides his magnetic works and astronomical discoveries—among which was the discovery of the acceleration of the moon's mean motion, and the method of finding longitude at sea—his principal works were the "Tabulæ Astronomicæ,' and an "Abridgment of the Astronomy of Comets," in addition to his "Catalogus stellarum Australium" before mentioned. We are also indebted to him for the publication of several of the works of Sir Isaac Newton, who had a particular friendship for him,

and through whom some of his most important discoveries were made. Thus, for instance, the first evaluation of the mass of Jupiter is that of Newton in the Cambridge edition of the "Principia" (1713), inferred from Halley's observation of an emersion of Jupiter and his satellites from the moon's limb, giving for the denominator of the fraction 1033. (See "Nature," September 23, 1875.)

Such is a brief account of the talented Edmund Halley, the details of whose busy and varied life must be awaited with the utmost interest. It will, we are assured, be a source of gratification and pride to astronomers, and indeed to all scientific men, throughout the Anglo-Saxon dominions to unite in raising such a memorial as has been suggested by the organiser* and observer of the Mars Expedition in 1877, and at last we may expect to see Halley's Mount crowned with an appropriate memorial of the astronomer.

V. THE HEIGHT AND SPAN OF THE JAPANESE.

WE well remember that quaint little group of two-sworded, strangely-dressed, men, who in the 1862 Exhibition were pointed out as Ambassadors from that then almost *terra incognita*—Japan. The curious would saunter past these eastern islanders in order to form a comparative idea of the height of men whose ample skirts made their height appear greater than their, in truth, diminutive stature warranted. China has since sent us for exhibition the gigantic "Chang;" but Japan, though puzzling us with its clever legerdemain and fascinating us with beautiful *objets d'art*, has as yet not shown us that it can produce men of fine growth. Possibly the Japanese agree with Shakspeare, that "Small herbs have grace," whilst "ill weeds grow apace," for it would appear that many of the probable causes of their smallness are directly due to their own agency.

The data that we have for estimating the height of the Japanese are more exact now than the rough measurement above alluded to. Mrs. Chaplin Ayrton, M.D., has recently

* David Gill, Esq., F.R.A.S., Astronomer Royal at the Cape.

published* the results of nearly three hundred observations of the height and span of the Japanese. She found the average height to be 5 feet 3 inches, and their span 4 feet 11 inches. In the case of twenty-four women, taken at random, the tallest was a trifle over 5 feet 2 inches, and the average was 4 feet 8 inches, with an average span of 4 feet 6 inches. The shortness of the span as compared with the height is a general characteristic that is especially marked in the case of the women. This gives rise to the theory whether the habit of raising the shoulder-pole for carrying burdens, and the universal practice of tying the infant to the back, may not—by making the arms unused to great muscular exertion—arrest, in a measure, their development.

From the tables of height given the Japanese appear to be not only much smaller than the western nations, but also less variable in height. This may possibly be due to a less great mixture of races than now exists in Europe. During four years Mrs. Ayrton appears to have only seen one Japanese who struck her as exceptionally tall, a circumstance that in any European capital could not have failed to happen more frequently. Taking the percentage of the observations, 60 per cent of the Japanese observed had the span shorter than their height, 33 per cent had the span greater than their height, whilst in only 6·8 per cent was the ideal of proportion realised, namely, that the height and span shall be equal. It is to be regretted that the more complex measurements of the head, &c., were not taken, but possibly the docility of the subjects experimented upon would not have admitted of very detailed examination, as it seems the Japanese have a strong superstitious dislike to be measured, and even object frequently, on the same grounds, to be photographed.

In seeking the explanation of the smallness of the Japanese it is proverbially known that climate is often called to account. Doubtless climate has much to do with the stunted growth of Laplanders and Esquimaux, but Japan occupies a temperate zone. Granted, however, that the climate of Japan is magnificent, still the seasons are more marked and the variations of temperature more sudden than with us, and the question arises whether the sudden demands made upon the organism to accommodate itself to such variable atmospheric conditions may not be unfavorable to harmoniously continuous growth. The clothing of a nation illustrates very

* "Recherches sur les Dimensions Générales et sur le Developpment du corps chez les Japonais."—Thesis for the degree of Doctor of Medicine presented and sustained by Mrs. CHAPLIN AYRTON before the Faculty of Medicine of Paris.

fairly the conditions under which they live, and in Japan we find the system of dress to consist essentially of many layers of similarly made garments, the characteristics of which are that, being loose and having one tie each, they can be readily taken on and off; and the abdomen is protected by a long and thick sash. In all variable climates, as in Spain, great advantage has been found to result from keeping the middle of the body well protected. The Japanese of the upper classes usually peel themselves of layers of their loose clothing towards the middle of the day, resuming the garments as evening closes in; whilst the coolie, whose wardrobe is less extensive, casts towards noon his cotton dress in favour of his tattooed skin, and is to be seen in the evening only comfortable in a wadded coat.

The use of charcoal braziers is probably an unhealthy custom; for although Japanese rooms are habitually open to the air in the daytime, still the custom of sitting for many hours with the mouth almost directly over the brazier cannot but lead to a considerable amount of the poisonous oxides of carbon being inhaled.

The physique of the Japanese does not tend to inspire confidence in a vegetarian *régime*, upon which, with fish, this people may be said to live. However, they also eat their vegetables highly salted; and we know that sailors, who, under otherwise healthy conditions, yet eat much salted food and live in an atmosphere impregnated with salt, are usually of a short square build. Thus it may possibly be the salted nature of the food, rather than the absence of meat, that is deleterious to growth. Again, with regard to diet, the growth of the children appears to bear a favourable comparison with European children in infancy, when they are nursed even up to three years old, but to become unsatisfactory during the later period of childhood, seeming to indicate that the food supply—although equal to the demand for simple existence—is insufficient during the period of the body's most active growth. It seems probable that the direction in which the food is insufficient is in fatty matters, for, as regards the nitrogenous element, beans, which contain much vegetable albumen, are largely consumed by the Japanese. Of course, however, many of the additional causes of the smallness of the Japanese may be so remote as to cease to affect the nation except by hereditary influence. It appears that authors are agreed that the Japanese are a mixed race. Hilgendorf states that at least one-third of the Japanese skulls are provided originally with a double jugal bone, which remains more or less at a later period, and which might

almost be called the "os Japonicum." We know of no observations that connect this cranial peculiarity with the type of face to which it belonged during life; but if, as Mrs. Ayrton thinks, the Malay, Chinese, and Aino types can in the modern Japanese be detected by practice and attentive observation, it might be possible, and would be most interesting, to ascertain to which national element might be attributed a peculiarity which so careful an observer as Hilgendorf considers so indubitable a characteristic of such a large portion of the people of Japan.

This thesis of Mrs. Chaplin Ayrton brings us back to the history of the attempt made by women during the last ten years to obtain a higher education. In 1869 the University of Edinburgh opened its matriculation examination to women as well as to men, and five ladies passed this examination, and became each a "Civis Edinensis." But to pass the various examinations at the University of Edinburgh, not only is a certain standard of knowledge necessary, but the candidate must produce certificates of having attended certain courses of lectures within the walls of the College. Joint classes of men and women were, however, specially forbidden by the Faculty, and separated courses for so few women were unattainable. Hence after a four years' residence—during which the five and some other girls who had now joined them had, in open competition with the men students, obtained prizes and scholarships, not only at the University, but also at the Royal College of Surgeons, Edinburgh—the small band of women dispersed, many with their well-earned laurels, but all without the much-coveted but unattainable degree. One of them, the writer of the thesis we are reviewing, went as a pioneer to Paris, to see whether there she could obtain the medical education denied her in her own country. In recognition of her four years' academical course at the University of Edinburgh, the Paris Faculty awarded her the honorary degrees of "Bachelier ès Sciences" and "Bachelier ès Lettres," and allowed her to commence the complete course, which, after her subsequently passing the necessary seven examinations, has now been concluded by the award of the degree of Doctor of Medicine on her presenting and sustaining her thesis.

VI. ENGLISH AND AMERICAN PHYSIQUE.*

By GEORGE M. BEARD, M.D.

II.

Civilisation, Climate, and Teeth.

THE American dentists are the best in the world; not necessarily because the Americans have greater mechanical skill than Europeans, but because the early and rapid decay of teeth in Americans of the better class have compelled them to give special attention to dentistry.

This quick decay of teeth in America, like various forms of nervous diseases that go with this decay, is the result not of climate alone, but of climate combined with civilisation: the confluence of these two streams is necessary. Irregularities of teeth, like their decay, are the product primarily of civilisation, secondarily of climate: they are rarely found among the Indians or the Chinese, and, according to Dr. Kingsley, are rare even in idiots; the cretins of Switzerland, the same authority states, have "broad jaws and well-developed teeth."

Another fact of much instructiveness is, that decayed teeth in Indians and negroes are less likely to annoy and irritate than the same amount of decay in sensitive, nervous, and finely organised whites of any race. Coarse races and peoples, and coarse individuals, can go with teeth badly decayed without being aware of such decay from pain, whereas in a finely organised constitution the very slightest decay in the teeth excites pain which renders filling or extracting imperative. The coarse races and coarse individuals are less disturbed by the bites of mosquitoes, by the presence of flies or of dirt on the body, than those in whom the nervous diathesis prevails.

Nervous force travels more slowly, the reflex irritation is less perceptible by far, in the dark races and those who live out-doors than in those who live in-doors and are of a nervous frame. In the strong and coarsely built, local irritation remains local, and does not reverberate through the body; while, on the other hand, in the feeble, the sensitive, and the highly and finely organised, any local excitement is

* The first part of this article appeared in the January number of the "Journal of Science."

speedily transmitted and puts the whole system into disturbance.

The simple operation of sneezing illustrates this law in a most interesting and significant manner. It is said, for example, of the negroes of the South, that they rarely if ever sneeze. It is certain that the nervous, feeble, sensitive, and impressible of any race are far more likely to be provoked into sneezing from slight irritation of the nasal passages than those of an opposite temperament. In hay-fever sneezing is one of the leading symptoms, and is provoked by irritations in themselves of the most trifling character, which those not victims of the disease can only be forced to believe by a personal battle with this enemy of the race.

Differences of Climate.

These psychological differences come mainly from differences of climate, and secondarily from institutions. In Great Britain and Central Europe there is no summer and no winter, as we in America are accustomed to understand those terms. Warm days they have, but not, as with us, a succession of days that are hot and oppressive during all the twenty-four hours. In the valleys of Switzerland, and in Great Britain, there are days that are called very warm, but which we in America would regard as simply comfortable, followed by nights of agreeable and delightful coolness; and this coolness comes on as early as four or five o'clock in the afternoon: people do not suffer from the continuity of heat and deprivation of sleep. A well-known physician of London told me that he made no change in his clothing all the year round, dressing in August very much as in February. One who should attempt this in New York would desire to perish.

The European climate allows more out-door life than American—not only in Paris, where many pass the larger portion of their time in the open *cafés* and on the boulevards, but in Ireland, England, and throughout Germany, men, women, and children pass far more time in the out-door air all the year than in the United States. The climate allows them to do this, and encourages it, while in America the winters are so cold and the summers so hot, and the twilights so short, that we are forced to stay under a roof. We do have a certain number of days in June and October when it is pleasant and inviting out of doors, when it is possible to sit in the open air, after the European mode;

but these days are so small a minority of the whole year that they do not foster or inspire a habit of out-door life; thus, we stay in-doors even more than is necessary in our own climate. One of the great advantages, possibly the chief advantage, in many cases, change of air for consumptives, is that they live out-doors; and, provided they can get an abundance of out-door air, it matters less than many suppose where they go—whether to the mountains or to cold or warm climates.

Not only are there many more days of rain in Great Britain than in America, but there are more clouds in the sky, even when it does not rain. Clouds, by well-known physical laws, interfere with evaporation; and thus the dampness remains longer in the earth than in a land where sunshine is more free. Thus, the number of days of rain and the amount of rain being the same in Great Britain and America, Great Britain would be more moist. This persistent moisture, as is well known, is the cause of the greenness and long-continued beauty of the foliage of Great Britain, of Ireland, and of the Scottish lakes. Certain threads and cloths, I am told, can only be manufactured at the highest advantage in this moist atmosphere.

My friend Professor Ball, of Paris, told me there is a great difference between Great Britain and France. In Paris, at least, where the sky is far clearer, more like that of America, the streets dry up much more quickly after a rain. The French, as also is well known, are more nervous in some respects than the English, with a finer type of organisation, more nearly resembling Americans.

Either climate, that of Great Britain or of America, is hard at first to bear: when we become worn to either we prefer it to the other. I am told by one who well knows that quite a number of Englishmen and Scotchmen who have lived in this country and acquired property, returning to their homes, after a time came back to America; they missed the noise, the hurry, the struggle to which in the life of business they had become accustomed here, and the mother-land seemed dull and cold.

Americanisation of Europe.

Observations in both continents bring into view two processes that are of supreme import in their relation to the future of mankind. One is, the Americanisation of Europe, the other the Germanisation of America. That Americans were more rapid in their movements, more intense in their

whole life, and concentrated more activity in a certain period of time than any other people, has been the faith of all travellers, and this belief has a foundation of reality; but in Europe at least, and to a less degree in Continental Europe, we now observe the same eagerness, intensity, feverishness, and nervousness that have hitherto been supposed to be peculiarly American.

Particularly was I amazed by this when I was in Cork during the present year, attending a meeting of the British Medical Association. The labour of a month was compressed into a week. Every one was in haste—officers and members having only bits of time to breathe or speak; a procession of suppers, breakfasts, balls, banquets, scientific orations, garden-parties, and excursions at every point of the compass, crowded so closely as to tread upon each other's heels; after such a vacation one needed a vacation. At no gathering outside of political assemblages in America have I seen such excitement, such hurryings, such impatience, such evidences of imminent responsibility as among the leaders and officers of that meeting.

This Americanisation of Europe would seem to be the complex resultant of a variety of influences—the increase of travel and trade, and concentration, and intensifying of activity required by the telegraph, railway, and printing-press—the endosmosis and exosmosis of international life—a reciprocity of character. It is clear that even in Europe each generation becomes on the whole rather more sensitive than its predecessor, and in this pathological process even Germany shares; Switzerland, perhaps, being less affected up to the present time than almost any other part of Central Europe.

The nervousness of the third generation of Germans is a fact that comes to my professional notice more and more. Men whose parents on both sides were born in Germany, here develop the American type in all its details—chiselled features, great fineness and silkiness of the hair, delicacy of skin, and tapering extremities. Such persons have consulted me for all phases and stages of functional nervous trouble. Indeed, I have seen in my professional experience no more severe examples of nervous suffering than in this class. Englishmen, even those who were born in England, develop either in their own country, or in this, the land of their adoption, many of the prominent symptoms of functional nervous diseases that are supposed to be especially and pre-eminently American. I am told by one of the leaders of German science, Professor Erb, of Heidelberg,

whose opportunities for getting facts on this theme are exceptionally good, and whose capacity for observing and for reasoning justly from his observations is very great, that in nearly all parts of Germany there can be found at the present day, and that too without very much seeking, cases of functional nervous disease in all respects the types of what we see in America; and there has been of late years an increase in these disorders. Even Irishmen born in this land or brought here early are not entirely safe from the chances of nervous contagion.

Prose style is dying or sleeping in Great Britain; the countrymen of Milton and De Quincey must cross the Channel if they would seek for living models of the literary as for the dramatic art. Literature takes its inspiration from the multiplication table, the newspaper supplying at wholesale the words, phrases, and witticisms with which the authors clothe their borrowed thoughts. Suggestions, intimations, and adumbrations of the literary art are seen, but they are crushed under mountains of everydayisms. What everybody will read within twenty-four hours, what nobody will read after twenty-four hours, is the motto that rules the best periodicals in Great Britain: each issue washes out the preceding; the monthlies follow each other with haste, like waves beating upon the shore, and, like them, are quickly lost in the sea of forgetfulness everlasting.

Science, which in its highest phases is but poetry and philosophy in harness, is, in Great Britain, better than its literature; but, in nearly all the great realms of science, England would starve were she not kept constantly nourished at the breast of Germany. Outside of the circle of men of pure genius, like Crookes, the scientific men of England feel that they have reached the highest possibilities when they have given popular lectures on what Germany discovered from five to twenty-five years ago. The profession of medicine—a part of science—lies near the bottom of the middle class, buried under successive strata from royalties and nobilities through the church, the army, the navy, the bar, and successful trade. The descendants of Young and Newton and Harvey are organising to drive a part of experimental physiology from the empire.

As literary art declines in England, the oratorical art seems to rise. Even speakers of but little fame are, many of them, easy and flowing, at times rapid as well as clear in their utterances; so much like Americans that only peculiarities of speech suggest the land of their birth.

Fear of new sciences and philosophies is a most interesting

evidence of the Americanisation of certain classes in Great Britain. This stout and virile people, so bold in adventure and in battle, tremble in the presence of new ideas—as the savages whom they conquer and subdue, on the approach of a storm. The scientific discoveries of Germany are a terror; they fear an irruption from the Continent which may overwhelm and bear away their philosophic heirlooms; and their great effort is to erect and guard a line of defence, to keep back the surges of new truths, as the Dutch make dykes against the inroads of the sea.

Thus it is that men in the highest stations, either in church or politics, are always under arms, expected to do duty against the invasions of Continental philosophy. Half the literature of the last quarter century of Great Britain, outside of fiction, is devoted to proving the truth of the untrue and the undemonstrable. Their very best men will probably soon begin to see that this chronic alarm is needless. Superstition is always safe—ignorance everywhere is its own protection; in all the conflicts between intellect and emotion, intellect—with here and their an interlude—is almost sure to be worsted and trampled upon. The demonstrably false can always be trusted to take care of the things of itself; it is truth alone that has cause to be afraid. Science, along all its lines, is open to attack, in peril even of its existence—none of its facts being so walled about as the unproved and the untrue. Truth is a plant as sensitive and tender as it is precious and rare; like all noble and highly developed organisms, it is liable to fatal injury and quick decay: bitten by frost, choked by weeds, broken by storms, the object of attack for all the non-expertness of mankind; error alone has the elements of enduring life. On this tossing sea of humanity, families, tribes, peoples, nations, and empires rise and fall in endless pulsations—arts, literatures, sciences, discoveries, philosophies appearing for a moment on the crest of the waters, then sinking into the fathomless depths; but over all, unchanged save in form, rests a cloud that through the ages never lifts, and a darkness that is scarcely illumined but by the momentary lightnings that flame on its borders, and fugitive glimpses of the distant stars. It is the undemonstrable, and the demonstrably false, that have ever ruled mankind, and are destined to rule it. The superstitions and mythologies of Egypt are read in the hieroglyphics on her temples and pyramids and monuments, but the arts that reared those structures have passed for ever from the possession of men; knowledge dies, while delusions live.

Germanisation of America.

The Germanisation of America—by which I mean the introduction, through very extensive immigration, of German habits and modes of life and pleasure—is also a phenomenon which can now be observed, even by the dullest and nearest-sighted, in the large cities of the northern portion of our country. As the Germans in their temperament are the opposite of the Americans, this change promises to be in most respects beneficial, encouraging in every way out-door life and amusements, tending to displace pernicious whisky by less pernicious beer and wine, setting the example of coolness and sobriety, which the nervously exhausted American very much needs. Quite true it is that the second and third generations of Germans do themselves become Americanised, through the effects of climate and the contagion of our institutions; but the pressure of immigration provides, every year, a supply of phlegmatic temperament.

The American race, it is said, is dying out; but there is no American race. Americans are the union of European races and peoples, as lakes are fed by many streams, and can only disappear with the exhaustion of its sources. Europe must die before America. In sections of America as in New England, and in large cities, the number of children to a family in certain classes is too small for increase of population; but these classes are a minority in society, and immigration is as certain as the future. Malthus forgot that the tendency of all evil is to cure itself; the poison and the antidote are rooted in the same soil. The improvement in the *physique* of the Americans of the most favoured classes during the last quarter of a century is a fact more and more compelling the inspection both of the physician and the sociologist. Of old it was said that the choicest samples of manly form were to be found in the busy hours of the Exchange at Liverpool; their equals, at least, now walk Broadway and Fifth Avenue. The one need for the perfection of the beauty of the American women —increase of fat—is now supplied.

The true philosophy on this as on all themes is neither optimism nor pessimism, but *omnism*, which sees both the good and the evil in nature, and aims to make the best of both. America is now on the borders of its golden decade, in which the forces that renovate and save will be far mightier than the forces that emasculate and destroy.

The typical American of the highest type will in the near

future be a union of the coarse and the fine organisations; the solidity of the German, the fire of the Saxon, the delicacy of the American flowing together as one—sensitive, impressible, readily affected through all the avenues of influence, but trained and held by a will of steel; original, idiosyncratic, learned in this—that he knows what not to do, laborious in knowing what not to do; with more of wiriness than of excess of strength, and achieving his purposes not so much through the absolute quantity of his force as in its adjustment and concentration.

ON WATER AND AIR.*

By JOHN TYNDALL, D.C.L., LL.D., F.R.S.,

Professor of Natural Philosophy at the Royal Institution of Great Britain.

LECTURE II.

YOU must be disposed to imagine that water, because it is so easily movable or so easily tossed aside by the hand in passing through it, would be, like air, very compressible, and that you could squeeze it into a smaller space. Now this would be a gross error. Notwithstanding this wonderful mobility that it possesses, it is almost incompressible. The first attempt to compress water was made in the year 1620, by the illustrious philosopher Bacon. He wanted to ascertain whether water was, like air, capable of compression, and he operated thus:—He got a globe of lead similar to that which I have here. This was made for me by my exceedingly obliging friend, Prof. Abel, of Woolwich. This is exactly the first form of Bacon's experiment when he attempted to compress water. He filled the globe of lead with water, and he placed it upon an anvil. He then took a great sledge-hammer, as I do now, and endeavoured to squeeze the globe of lead into a smaller shape; he beat the lead again and again, and tried to compress the water. Well, he did compress it to a certain extent; but he found, as he himself in his own quaint language expresses it, that the water, impatient of further pressure, finally exuded through the lead and covered the surface of the globe like a dew. Here, then, we have an instance of the incompressibility of water as evidenced in Bacon's first experiment. Nearly fifty years afterwards a similar experiment was made by a member of that great Academy, the Accademia del Cimento, of Florence. They used a silver globe instead of a lead globe, and, on account of the Academy having published a description of the experiment, it usually goes by the name of the Florentine experiment. But it has been

* Being a Course of Six Lectures adapted to a Juvenile Auditory, delivered at the Royal Institution of Great Britain, Christmas, 1879. Specially reported for "The Journal of Science."

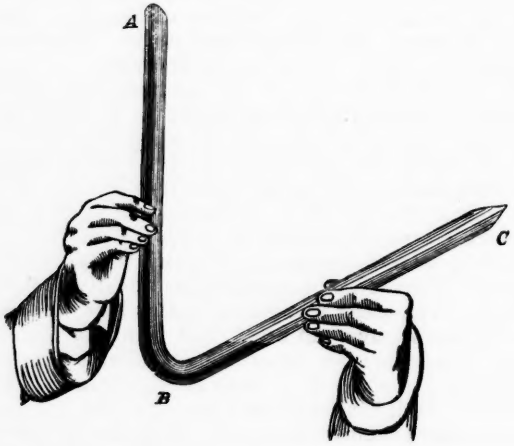
shown by my excellent friend, Mr. Spedding, and his distinguished and eminent colleague, Mr. Ellis, that nearly fifty years prior to the experiment in Florence it had been made by Bacon; and therefore, instead of being called the Florentine experiment, it ought really to be called the Baconian experiment.

In our last lecture we had some experiments illustrating the tenacity of water. Well, this tenacity is enormously increased if you repel the air from the water. Take a flask of water, heat it over a spirit-lamp, and you will always find, after a certain time, bubbles coming from the water, and condensing like bubbles of steam. They are small bubbles of air held in solution by the water. If you rid the water of this air, if you get the air from between the particles of water, you enormously increase its tenacity, and it has very many peculiar properties when it is thus rid of the air. For instance, here is a quantity of water contained in this tube, and if I bring the water into one end of the tube and turn it down you hear that the water rings like a solid. [In this experiment the water was contained in a glass tube called the water-hammer, from which the air had been expelled.] This is water that has been deprived of its air by boiling. The water was placed in this tube, and one end of the tube was drawn out nearly to a point, for the steam and air to escape through the orifice, and after a certain amount of boiling the orifice was hermetically sealed. This water, as I have said, has far greater tenacity than ordinary water, and in order to demonstrate this I have here a glass V-shaped tube (A B C, Fig. 4) which illustrates a series of experiments made by a distinguished man in Belgium, M. Donny. He showed that when water is deprived of its air the tenacity of the water is enormously increased. You see that, as I turn the tube, the water rests at the same level in the two legs of the tube. If I hold the tube in one way the water goes into one leg, and if I hold it in another way the water goes into the other leg. Now this tube has been deprived of its air in a somewhat similar manner to the water-hammer, as it is called, that I have just shown you, and you hear that the water rings when I bring it into contact with the interior surface of the tube.

Now what I want to show you is that, if I really bring that water into close contact with the interior surface of the tube, it will not flow back: there it will cling, and the particles of water will so hold on to the glass that the water will not flow from one end to the other. When I first turn down one end of this tube you observe that there is a little

ring. The sound is not quite dead. [The water having been brought into the leg of the tube (A B), the tube was gently tapped on the lecture table, so as to cause the water to adhere more closely to the interior.] Now the sound is very dead indeed; and I have got the water in contact with the tube that contains it. Now I will lift it up carefully,

FIG. 4.



and you observe that the water no longer stands at the same level in both tubes, but fills the leg of the tube A B altogether and leaves the other quite empty, and that is because of the tenacity of the particles of the water which are clinging to the sides of the tube, the water having been deprived of its air.

Now, let me be perfectly exact. I have said that the water gets rid of this air by boiling; but some years ago a series of experiments was made by Sir William Grove, which seemed to show, or which at least justified him in saying, that he believed that we never saw boiling water at all in the proper sense of the term. He has sometimes boiled water not for hours only, but for several days. When you rid water of its air, as M. Donny did, you can heat it to a temperature far beyond the ordinary temperature of boiling water, and from time to time it gives as it were a

sudden leap. When you attempt to boil it, it leaps almost out of the vessel in which it is contained, if it be freed from the air. Well, Sir William Grove found that he got, not this regular, tranquil, continuous boiling, but a series of sudden leaps in his boiling, due to a sudden generation of a quantity of steam; and he found that he never could get a bubble of steam that condensed entirely in cold water or in the cold oil that he had above the water. There was always a little air; and when he examined it he found it to be a particular portion of air,—that is, the nitrogen,—so that he never could get a bubble of steam without this bubble of gas. He came to the conclusion that if you could entirely free water of its air you never could get boiling at all. It would be heated up until it would be chemical)y decomposed instead of undergoing ordinary boiling. Well, so much for the tenacity of water and its non-compressibility.

I have now to say one or two words more with regard to the colour of water hinted at in our last lecture. You know that on that occasion I formed a brilliant spectrum upon the screen, and that I took this vessel—which consists of three cells,—and filled the thin cell with a slightly coloured liquid, which had hardly any effect upon the spectrum. I then filled another cell, and that cut off a third of the spectrum. I then filled the thickest cell, and it cut off practically the whole of the spectrum. You had there an example of the effect of the deepening of the layer of water in quenching the light. Now I am going to introduce to you a problem which is not usually introduced into lectures, but I think that it is one which you will easily understand, and which is worth understanding. Here is a black liquid. It is, in fact, a quantity of ink. The light shines upon it from the top of the house, and it strikes the surface of the liquid, and as I look into it I see the image of the gaslights overhead: that is due to what is called surface reflection. The ink reflects light from its surface, but this is simply some of the light that falls upon it. The light that gives a body its colour must go into the body to a certain depth, and be ejected from the body minus some of the constituents of white light; but the light which comes from the surface of the body is simply white light. Why is this ink black? Simply because there is no ejection of light from the interior of the liquid. No light comes from within. You have only surface reflection, and therefore the liquid is black.

And now let us reason together. Suppose you stand upon a ship's side and look down into water two or three thousand fathoms in depth—the deep, deep, perfectly pure sea. That

water is perfectly clear. I mean that it is water without any mud or suspended matter in it, but still capable of colouring light, as was the water which was shown here in our last lecture. Well, I say take water pure enough and deep enough to allow the whole of the light to plunge into it until the whole spectrum is extinguished. You see plainly that that water would not differ from our ink. You would have surface reflection, but you would have no light from the interior of the water. The colours of the spectrum would be quenched, and the consequence is that you would have practically a black liquid, no matter how transparent the water might be. Now, if any of you ever cross the Atlantic, or even cross the Bay of Biscay, you will find that in certain deep portions of the sea the water approaches a fine shade of indigo, and it is sometimes almost as black as ink. I remember the late most excellent Mr. Charles Kingsley writing to me about this. He said that nothing impressed him more, in crossing the Atlantic, than the wonderful blackness of the sea. But you see that the cause of this is that the water is exceedingly pure and exceedingly deep,—so deep that the sunlight, when plunged into it, is actually quenched within the body of the water, and none is sent back to the eye. The same thing occurs practically in some of the moraines in the Swiss glaciers, where the ice is exceedingly pure and exceedingly deep. Looked at superficially that ice is almost as black as pitch. Break a piece off it, and look through it, and it is almost as transparent as crystal. And so with regard to the Atlantic water, which looks so inky black. If you take it in a glass you will find that it is as transparent as possible.

Now, whence come the varying colours of the ocean water? You sometimes see it a vivid green, and sometimes a yellow-green. In 1870, when I went to Algiers to try to observe a total eclipse of the sun, I tried to solve this question, and in order to do so I took this white plate that you see here before you, which you see is weighted with a leaden weight; and here is a portion of a long rope which was used in the experiment. My object was to account for the extraordinary changes that I observed in the colour of the sea. I have observed them since in crossing the Atlantic from the banks of Newfoundland. For instance, you pass from water which is of this deep indigo, or almost as black as ink, into water of a vivid green; and in going from Gibraltar to Spithead the variations in the colour of the water were extraordinary. I operated in this way in order to instruct myself upon the subject, and in order to ascer-

tain why one water should be green and another almost black, or, at the least, of a shade of indigo. A very good fellow, named Thorogood, was lent to me by Capt. Sanderson, who was the commander of the vessel in which I sailed. The man, who was accustomed to heave the lead, used to get into a boat near the front of the vessel, and I went towards the stern, and this man then used to heave the plate out. Being weighted it sank rapidly, and by the time it came to the stern, where I was standing, it was at a good depth. Immediately after it entered the water it became green: that green deepened, and approached a black; but I never saw it properly blue. It was a blue-green at the most, and that was at the utmost depth. That, then, was the colour of the water at the particular depth to which the plate reached.

Now I think that you will be able to follow me. The water at a certain depth coloured the plate of a vivid green. Supposing that that plate had been broken into fragments, and the fragments thrown into the water, each fragment would have sent a modicum of green light to the eye; there would be seen a number of green spots in the water. Suppose that, instead of being broken into small fragments, the plate had been ground into a powder so fine that it would remain suspended in the water; every particle of that powder would send its modicum of light to the eye, and the consequence would be that the water with such particles diffused through it would appear to be green water. You see, by the experiment which I made in the blue-black water in the Bay of Biscay, that I produced a green colour by means of the white plate. I am now going on, by the process of reasoning, to deduce the fact that if I ground the plate into powder, and diffused that powder through the water, the water would appear green by reason of the light reflected by the little particles of powder to the eye.

Now this completely accounts for the colours of the ocean observed between Gibraltar and Spithead. It was sometimes a dull yellow-green, sometimes a bright emerald-green, sometimes a cobalt-blue, sometimes an indigo colour, and sometimes almost as black as ink. I took samples of all these waters in clean stoppered bottles, and by sending a powerfully concentrated beam through them, here, in London, examined their condition. The blackest water, which was taken from the deepest portions of the Bay of Biscay, was the purest. After it, in order of purity, came the indigo, cobalt, bright green, and yellow-green water. The water last named was thick with suspended particles, while the

Bay of Biscay water was almost wholly free from them. In the green water the particles were very fine, but so numerous as to send an apparently unbroken green light to the eye. In deep water the particles rest tranquilly at the bottom, in shallow or shoal water they are stirred up by the agitation of the sea. Shoal water, therefore, is always green to the eye. Thus we connect the colours of the sea with its mechanically suspended matter.

The following table clearly shows the connection between the colour of the sea and its suspended matter :—

No.	Locality.	Colour of Sea.	Appearance in Luminous Beam.
1.	Gibraltar Harbour	Green	Thick, with fine particles.
2.	Two miles from Gibraltar	Clearer green	Thick, with very fine particles.
3.	Off Cabreta Point	Bright green	Still thick, but less so.
4.	Off Cabreta Point	Black-indigo	Much less thick, very pure.
5.	Off Tarifa	Undecided ..	Thicker than No. 4.
6.	Beyond Tarifa	Cobalt-blue	Much purer than No. 5.
7.	Twelve miles from Cadiz	Yellow-green	Very thick.
8.	Cadiz Harbour	Yellow-green	Exceedingly thick.
9.	Fourteen miles from Cadiz	Yellow-green	Thick, but less so.
10.	Fourteen miles from Cadiz	Bright green	Much less thick.
11.	Between Capes St. Mary and Vincent	Deep indigo	Very little matter, very pure.
12.	Off the Burlings	Strong green	Thick, with fine matter.
13.	Beyond the Burlings ..	Indigo.. ..	Very little matter, pure.
14.	Off Cape Finisterre ..	Undecided..	Less pure.
15.	Bay of Biscay..	Black-indigo	Very little matter, very pure.
16.	Bay of Biscay..	Indigo.. ..	Very fine matter, iridescent.
17.	Off Ushant	Dark green..	A good deal of matter.
18.	Off St. Catherine's ..	Yellow-green	Exceedingly thick.
19.	Spithead	Green	Exceedingly thick.

Now I want to show you the effect of this suspended matter, and I cannot do it better than by showing the effect of our beam upon the dust of this room. The atmosphere always contains some suspended matter, and even rain-water and the clearest ice are not absolutely pure.

[In illustration of the purity of water taken from melted ice, the apparatus (Fig. 5) was shown and explained. A glass funnel, passing air-tight through a glass plate, has attached to it a glass bulb B, fitted with a stopcock. A block of ice, of great purity, had some days previously been placed in the funnel, and covered air-tight by a glass receiver. This receiver was connected to an air-pump, and the air removed from the interior of the apparatus. Air was then allowed to enter the apparatus by passing slowly through a tube containing cotton-wool. By this means the entering air was completely filtered of its floating matter. The ice melted, and the water trickled down the funnel into the bulb. When the latter was full the stopcock was opened,

and it was emptied, the water carrying with it in suspension any contamination that it had obtained from the sides of the funnel and bulb. This washing process was repeated several times, when, from the very heart of the ice, the

FIG. 5.

water was finally taken, and on examination by the concentrated beam it was found to be of a most delicate blue colour, proving it to be of the greatest purity.]

If we now send a beam from our electric lamp across the room, we shall illuminate the suspended dust. [An electric beam was made to traverse the theatre from the lamp at L, and brought to a sharp focus at *b*, Fig. 6.] Here we have our beam; that dust which you see in its path is nearly all combustible matter. The beam is fairly vividly shown upon the dust of the room. Now I will take something that will enable me to do away with the dust of the air. [A colour-

less gas flame was held underneath the beam at the focus *b*, immediately destroying its luminosity and producing a space of intense blackness.] Now you see these extraordinary black wreaths that go up into that beam. What are they? You would imagine that they were the smoke of the flame, would you not? But they are not at all. If I were to throw smoke into the beam, the smoke would appear quite white. I will try. We will strike a match and allow it to burn beneath the beam. [The smoke of a burning match was allowed to ascend into the electric beam, and appeared as a white cloud.] The blackness which you saw was not smoke at all. The black appearance was due to the air having been deprived of its floating matter. That floating matter is combustible, and when it is burnt away, and the air from which it has been burnt ascends through the beam, this blackness is produced as if there were a dense black smoke, although, as I have said, it is not smoke at all, for smoke actually produced whiteness instead of blackness.

Now, I want to enable you to compare the water of Canterbury with the water from our own cistern. I explained to you the nature of the Canterbury water in our last lecture. We have some of it in this flask, and in this other flask we have some of the water from our tap which is supplied, I believe, by the Grand Junction Water Company. For a long time past we have had but very little rain until to-day, and the consequence is that the tap water at the present time is exceedingly good. It is comparatively clear, for we have it now at its best. If you read the reports in "The Times" and in other newspapers, you will find that the water supplied to London is now very good indeed, and very free from suspended particles. A beam of light will be made to pass through these flasks, so that you may judge of the comparative purity of the water. I think you will find a great predominance of purity on the part of the Canterbury water. I am now going to light a very famous candle—the Jablochkoff candle as it is called. Right and left of the candle are placed two lenses so as to concentrate the light within the flasks. [The two flasks were illuminated as described, the course of the rays of light being perceptible in both flasks.] If the water were absolutely pure you would see no track of the beam in it. The green which you see in the flasks is due to the suspended matter of the water. In the Canterbury water you have a considerable amount of suspended matter, but there is less than in the tap water, notwithstanding the fact that the tap water is now in its very best condition.

I have now to refer to water in motion—to jets or veins of water, as they are sometimes called; and in order to begin

FIG. 6.

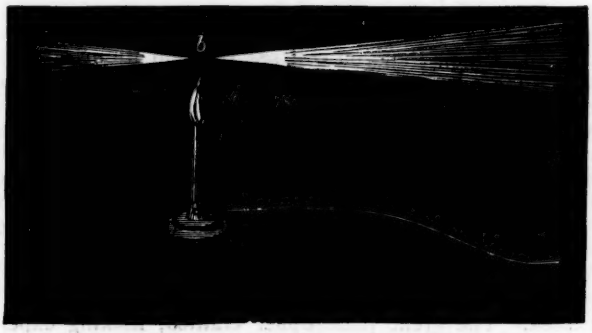
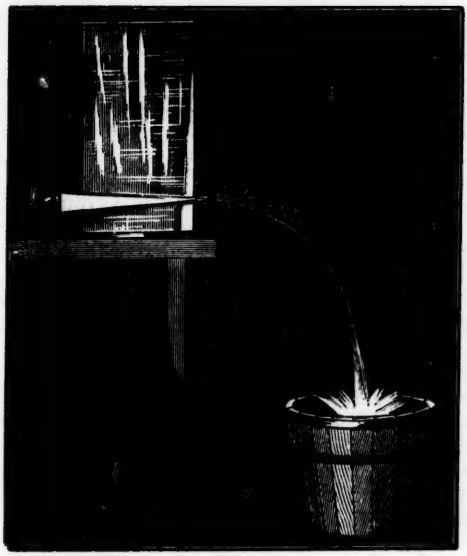


FIG 7.



this, I will try to show you a jet of water coming out of this reservoir which is placed behind me. Mr. Cottrell is going

up to where that vessel stands. He has placed behind it an electric lamp. It gives an intense beam of light. I want to show you, first of all, simply the vein of water flying out of this vessel. Mr. Cottrell will send into that vein a condensed beam of light. The light goes into that vein and cannot get out of it, and will be carried down with the water, and I hope that you will see the vein illuminated by the internal reflection of the light. At the back of the vessel there is a little glass window, and through that window the beam is sent, so that it will fall exactly upon the orifice at which the vein of water will run out. Mr. Cottrell will withdraw the cork from the vessel and the illuminated water will rush down. [The theatre was darkened, and upon the cork of the vessel being withdrawn the illuminated water descended like a stream of liquid fire. Fig. 7.]

Well, here you have a continuous vein flowing out in this way, and forming the curve which mathematicians call a parabola. The great philosopher Galileo, making experiments at Pisa on the celebrated leaning tower of which all of you have heard, established what we call the laws of falling bodies. He determined the laws obeyed by bodies when they fall, and his celebrated pupil, Torricelli, connected those laws of Galileo with the outpour of a vein of water of this kind. You will understand immediately the law which rules this vein. If I allow a leaden ball to fall from a certain height to the ground it reaches the ground with a certain velocity. If I allow it to fall from a greater height it reaches the ground with a greater velocity. If I allow it to fall from the top of the house it would reach the ground with a still greater velocity; and it is on this account that bodies falling from a great height are more destructive than bodies which fall from a lesser height. Now, Torricelli proved that the velocity of the water issuing from that orifice is exactly that which would be acquired by a body falling from the top of the vessel to the orifice. From that velocity it is able to describe this beautiful parabolic curve.

Now we have to consider other veins which, unlike that we have just seen, are not continuous. If you allow water to flow from an aperture in the bottom of a tin vessel, you will find that the vein of water divides itself into two distinct portions. You have first of all a portion that appears perfectly tranquil—almost as tranquil as a glass rod. A little below that part you will find the rest of the vein unsteady; but the vein of water appears always continuous throughout, although one part is steady and the other unsteady. Now,

that continuousness of the vein is an illusion, and it has been the subject of examination by very distinguished men. What is the cause of this change in the character of the vein from steadiness to unsteadiness? Mr. Cottrell has here arranged an experiment which shows a very remarkable property of fluid bodies, and which illustrates the shape which they assume if left free to choose their own shape. He is going to place some oil in a liquid in this vessel. It is very difficult to arrange this experiment. The liquid ought to be of exactly the same weight or specific gravity as the oil, and if it be so arranged you will find that when the olive oil is placed in this liquid it will exactly float in the liquid, no matter where you place it, without sinking and without rising, and you will find that the olive oil, free to choose its own shape, becomes a perfect sphere. The rain which you saw descending to-day when you were coming here appeared to be descending in lines or streaks. If such a rain shower could be illuminated with a single flash of lightning on a dark night you would see the rain drops, as perfect spheres, standing still in the air. The reason that they appear as streaks in the air is that the impression made upon the retina of the eye by every drop of rain lasts for a little time.

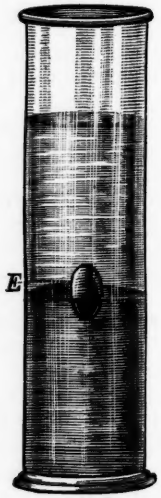
I have to thank my excellent friend Professor Dewar for giving you an illustration of what I now want to show you. There is an egg. That egg would sink in water. It would swim upon salt and water or brine, that is if the brine were made very strong. He has here made some brine, and that mixture is of exactly the same weight as the egg. The egg at present floats at the junction of the two liquids (Fig. 8), but it would float in any part of the column of brine where it might be placed. [From the bottom of the glass vessel to E was filled with the mixture of salt and water; from E upwards was filled with ordinary water; the egg is shown floating at the junction of these two liquids.]

Here is the olive oil which is arranged in the way that has been described. It has been dropped into a mixture of alcohol and water, and there you see they assume the globular form. If put into alcohol alone the oil would sink to the bottom, as it is heavier than alcohol. If poured into water the oil would rise to the top. Hence the necessity of getting a liquid with a specific gravity something between that of alcohol and that of water, in order to cause the drops of oil to float in any part of this liquid.

Now here I have to notice the investigation of that old blind philosopher, as Faraday used to call him, Plateau of Ghent. He has been blind, I believe, for nearly half a

century, and he has worked at these subjects and produced the most beautiful results from his investigations simply by having a good assistant, and directing his assistant to make his experiments for him, and to describe the results of those experiments. We might occupy a course of lectures in describing the experiments of Plateau. This experiment was devised by him for the purpose of withdrawing the oil from the "pull of gravity," as he calls it. A most extraordinary exhibition of the tendency of drops of water to assume this globular form is, I think, to be seen in the

FIG. 8.



whirlpool rapids some two or three miles above the Falls of Niagara. There you have a stream that drains half a continent. Those rapids are about a hundred yards across, and at part of the rapids you have great masses of rock on each side. The water impinges upon these masses of rock and waves are formed, and sometimes two waves coalesce in the centre of the river. One wave gets upon the other, and sometimes the contact is so violent that the crest of the waves is thrown into the air, and these beautiful water globules are produced. [A photographic view of the rapids was thrown upon the screen.] It is, of course, difficult to catch a picture at the very moment, but you can

imagine how the waves meet. This spray is due to the coalescence of two waves, both adding their force together, and tossing their crest into the atmosphere. It is simply a bundle of most beautiful spheres of water.

Now, as we must make our footing sure as we proceed, we will pass on from this to the consideration of a vein of water issuing from an orifice in the bottom of a vessel. As I said, this vein is composed of two distinct parts. One part is steady and the other unsteady, but the vein appears continous throughout. We can by a device which was made by that able man to whom I referred in our last lecture —Felix Savart—so illuminate a jet of water as to reveal the drops into which it resolves itself. The unsteady portion of the vein, though it appears continuous, is the place where the vein resolves itself into distinct spheres or globules of water. Savart made very particular observations upon this subject, and he found that this unsteady portion of the vein was composed of two different kinds of drops—large drops and small drops. Between every two large drops he found one or more exceedingly small drops. Now, I want to connect this appearance which was noticed by Savart with the explanation of this appearance which was given by the old blind philosopher, Plateau. Here is a little wire stand, and with the greatest ease we can put a quantity of oil upon that stand and cause it to assume a spherical form in this mixture of alcohol and water. Here is a wire formed into a circle. We will bring the wire down upon the sphere of oil and draw out the sphere into a cylinder. You can draw the cylinder up to a certain point, but infallibly at a certain point it cuts itself into two and forms two globes. By properly operating you can go on until you make the length of the cylinder a little more than three times its diameter. Beyond that point you can not go. The cylinder then infallibly nips asunder, as I have said, and forms globules. This is the limit of stability of a liquid cylinder. Now when a jet of water falls from an orifice in the bottom of a vessel, you have there a liquid cylinder; but you have that cylinder at a certain point resolving itself into drops. It will nip itself, and the nipping begins very close to the orifice which is left by the liquid. But it takes a certain amount of time to form the drops, and in the interval the vein is transported over a certain distance from the orifice from which the water issues. Now imagine this liquid cylinder nipping itself. The space between the two drops becomes a thinner and thinner cylinder. One drop separates, as it were, from the other, leaving a little thin or narrow cylinder between

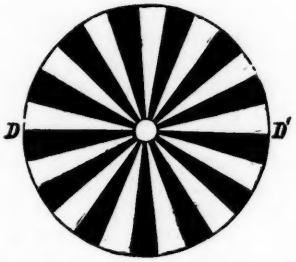
them. That little narrow cylinder finally breaks when the drops are perfectly formed, and it forms a little drop between the two larger drops. We have an apparatus which will enable me to show you this. Into the tall glass cell, C (Fig. 9), Mr. Cottrell has placed a mixture of alcohol and water. At the top of the cell he has placed a funnel, F, with its end dipping into the mixture. The funnel, fitted with a tap, contains a quantity of oil, and by turning on the tap

FIG 9.

we will allow the oil to issue from the funnel and slowly fall through the alcohol and water. There is a drop of oil coming from the funnel, and now you will see that it will become narrower and narrower, and that little central cylinder becoming very fine will break, and you will have a little sphere between two larger drops. The appearance of these spheres was explained not by Savart but by old blind Plateau. This is what Savart noticed in his first experiments upon liquid veins. I want to show you these drops,

if I can ; but before I do that I will tell you the meaning of what I have said about the persistence of impressions upon the retina. Every boy has burnt a stick and twirled it round so as to form a circle of fire in the air. The appearance of that circle is due to the impression on the retina. If you complete the circle in the fifth or the eighth of a second—for the time differs in different eyes—you see not simply the burnt end of the stick, but a circle of fire. The impression produced upon the eye when the end of the stick begins the circle is not extinguished until the end comes round again to its starting point; and thus you have a continuous circle of light. We can in this way mix colours in the eye. You saw the spectrum on the last occasion, and I told you then that if we were to mix all these colours together we should reproduce the white light from which that spectrum came. Newton's way of doing it was to colour a disc with what he called the primitive colours, and

FIG. 10.



then to impart the motion of rotation to the disc. If the motion be quick enough to enable the eye to retain the impression of all the colours during a revolution of the disc, then all the colours will be shown, as it were, simultaneously to the eye, and the colour will disappear, and the disc will be rendered white. This disc will now be turned, and you will see immediately that the colours will disappear. [A disc of card containing the prismatic colours in due proportions was caused to rotate with great rapidity so that the individual colours could no longer be distinguished, and the disc appeared white.] It is an experiment which I dare say most of you understand perfectly. Now, in place of the colour disc we will use a pasteboard circle with black and white segments. We might do this in a more perfect form with a larger apparatus, but I want to do it in a simple manner.

We shall illuminate this rotating circle with a series of flashes, and I will show you what you would see if you were to observe such a rotating disc by means of a single flash of lightning. The effect produced by flashes of lightning will be imitated here. When the disc turns round, the black and white will entirely disappear. [The black and white disc was caused to rotate, and at first illuminated by an uninterrupted beam from the electric lamp. Under these conditions the surface appeared of a grey tint.] You see that the black and white blend together in virtue of the persistence of the impression on the retina. I dare say some of the boys looking at it may turn their eyes or shake their heads in such a way that the disc may be resolved into its black and white sectors. We will now illuminate it with a distinct succession of flashes, and you will then see that it is no longer of a uniform grey. You see that every flash brings out the sectors so that you can see them separately as if the black and white disc were standing still.

Now if we take our liquid vein and illuminate it in that way, you will see it resolved into a series of beautiful liquid globules, and we are now going to try to illuminate a descending jet of water by means of a succession of flashes. These flashes are obtained by a disc of zinc, which is cut into radial slits, and is rapidly rotating before the electric lamp. You will see that as the jet of water descends a certain portion at the top is dark (*a n*, Fig 11), and the lower portion appears less dark. The less dark part is the unsteady portion. We see that at the less dark part the unsteadiness begins. That is the point at which the jet resolves itself into drops. [The jet of water was allowed to descend, and its shadow was thrown upon the screen.] Now we will try to illuminate the jet by means of a succession of flashes. If the repetition of these flashes of light be at the proper rate we shall be able to resolve the jet into drops. [The beam from the electric lamp was then caused to flash as indicated by means of the zinc screen.] You now see that the jet is resolved into drops, as I predicted (Fig. 12). I will now show you the effect of sound upon the jet. I blow a certain pitch with an organ-pipe, and that enables the vein of water to considerably shorten its continuous part. You see that the top of the vein shrinks when I blow a note. In this way we get an apparently continuous vein resolved into its constituent drops.

I have here in front of the table an arrangement which will enable me to show you the influence of sound upon the continuous portion, and also on the unsteady or discontinuous portion of the vein. If I turn the water on you see how

silently it flows. [A steady stream of water was caused to descend from a tap into a cup filled with water, about 2 feet below.] You see that beautiful stalk of water. The least agitation will break that vein, but at the present moment you have a continuous jet which enters the water below perfectly silent. I will now try the effect of sound. This vein of water is very sensitive indeed. It is very near the point at which it will resolve itself into drops. Now I simply draw my fiddle-bow across a tuning-fork, and instantly you see that the vein shortens,—several swellings and contractions form out of it, and we cause the drops to be formed high up in the vein, and you hear them breaking and bubbling in the basin below. If I stop the sound the vein becomes steady once more. If I draw the bow again over the fork you see how the vibrations of the sound cause the vein to resolve itself into beautiful liquid spheres. We have a resolution of the vein into drops by means of these musical vibrations. Savart, as I have said, investigated these subjects, but some of these things were not noticed by him.

Fig. 12.

Fig. 11.

The particular effect which I now wish to show you is a very beautiful one indeed, and which, I believe, we noticed here ourselves for the first time. We will allow a jet of water to issue from an iron nipple. Here we have our lamp, which will enable us to illuminate the jet as before. It requires very great care in order to cause the water to issue from the nipple with the proper velocity. [A jet of water was projected from the iron nipple (Fig. 13) upwards at an angle of about 60°, and fell over in the form of an arch, the further end of which became sprayed out as it approached the floor. The shadow of the jet was thrown upon the screen.] I will blow this organ-pipe near the jet, and you see that the broken portion of the jet is gathered up into a few small beautiful drops (Fig. 14). If I blow properly you see how the drops are gathered up altogether into one continuous line. [By varying the conditions the jet may be made to divide into two or

more bands, as shown in Fig. 15.] We will now make the shadow of the drops as large as possible by bringing the jet as closely as we can to our lamp.

I want now to illuminate that jet by means of our rotating slits. [The zinc screen mentioned in the former experiments was again put into action for the purpose of breaking the beam of light into flashes. The sprayed or unsteady portion of the falling jet was seen to consist of globules.] Now you see the drops very distinctly. Those who look at the drops themselves will see a greater amount

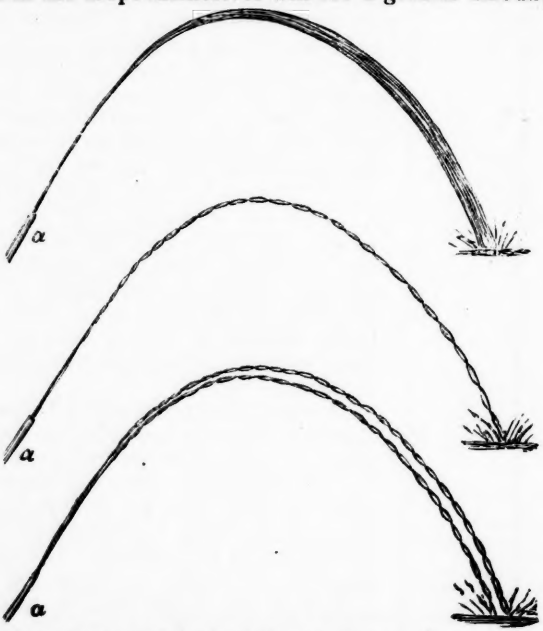


FIG. 13.

FIG. 14.

FIG. 15.

of beauty than those who look at the shadow on the screen. You observe that when I sound a note the drops become more distinct. [The note produced from the organ pipe not only rendered the drops more distinct, but caused the whole of the jet of water to change itself into a single line of globules.]

I have introduced these subjects to your attention in order to show you how beautiful are the commonest objects that can engage your attention when they are subjected to scientific examination. We shall pursue our work in the next lecture.

EXPLANATORY REPORTS ON NEW SCIENTIFIC PROCESSES AND INVENTIONS.

[These Reports will not partake of the nature of an Advertisement, but will be impartial descriptions, written and signed by well-known Specialists.—Ed. J. S.]

Hollway's Process for Reducing Metallic Sulphides without External Fuel.

Excepting in gunpowder, matches, and the Bessemer converter, the only elements hitherto used on a practical scale as artificial fuel have been carbon and hydrogen. This affirmation must, however, be limited in its application to the world in which we at present reside, as we are told of another place where the chief fuel is sulphur. Prometheus scaled Olympus, and from its celestial heights brought down upon lower earth the fire of the gods. Mr. Hollway has travelled in the opposite direction, and now shows us how we may here make use of sulphur as a fuel for the important work of smelting metals.

The combustibility of sulphur having been so long and so popularly understood, and the fact that it is so large a constituent of so many of the commonest ores of common metals being so well known, it is strange that this revelation should have been delayed so long.

The principle of the process is extremely simple. It consists merely in applying a small quantity of ordinary fuel to a natural compound of metal and sulphur, and having thus started the combustion, just as we use paper and firewood to start a coal fire, allowing it to proceed with the aid of nothing more than an efficient blast of air. Thus the sulphur which stands in the ore as the impurity to be removed effects its own removal by a fiery immolation, and the heat it gives out in this suicidal proceeding fuses, and in some cases completes the reguline separation of the metal.

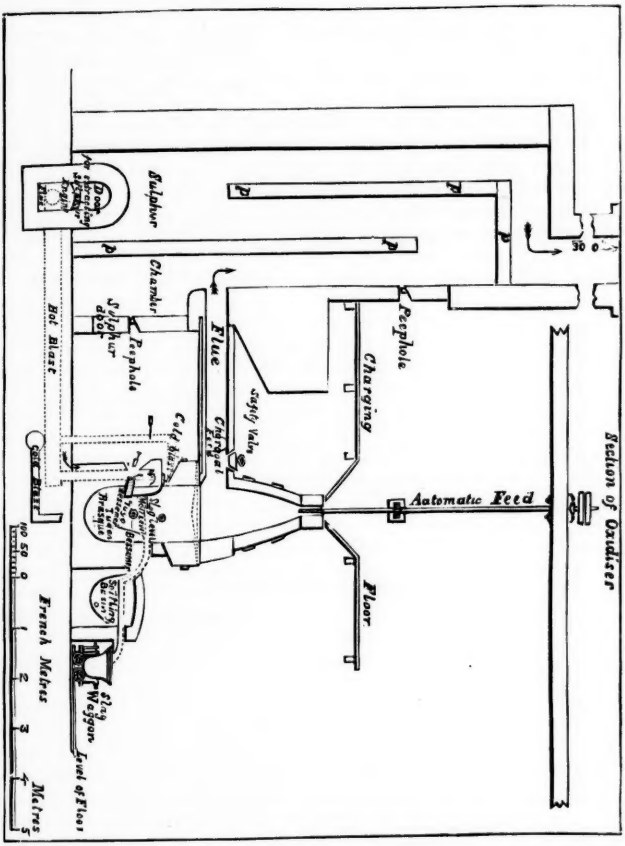
This extreme simplicity lies, however, all in the principle; the practical and profitable applications demand some ingenuity in devising the necessary apparatus and arrangements for conducting the process with the greatest possible economy, and utilising the by-products, the value of which constitutes an essential commercial feature of the invention. Unlike coal and other hydrocarbons, sulphur in burning produces a compound more valuable than the combustible itself. Besides the sulphurous acid produced by the combustion of the sulphur of the

metallic sulphides, a quantity of sublimed and unburnt sulphur is also thrown off, and this, being commercially valuable, has also to be collected and commercially shaped. Hence the practical problem has demanded considerable expenditure of ingenuity, labour, and capital. I have watched Mr. Hollway's struggles with these difficulties for some time past, with that hopeful sympathy which is so justly due to every genuine inventor, and therefore have received with much pleasure his latest reports of very promising commercial beginnings. These reports are accompanied with drawings of smelting-works erected in a country that has lately suffered so largely from the destructive combustion of sulphur that there will be poetical justice if a new and beneficent combustion of sulphur should develop its important mineral resources. The Bakarnitza Smelting-works, to which I allude, are at Madianpek, Belgrad, Servia. The general plan of the whole of these works need not here be reproduced, but the section of the Hollway oxidiser (see Figure) recently added to them elucidates at a glance the details of the process.

The sulphides to be reduced are spread upon the charging-floor on the right, and shovelled in sufficient quantity into the funnel-shaped depression of the floor. From this they are screwed down by the "automatic feed" arrangement, which can be obviously made to deliver at varying speeds, as may be required, and shuts off the escape of gases like the cup and cone of a blast-furnace. They thus trickle down into a sort of hearth or crucible, resembling the Bessemer converter in receiving a blast below the surface of melted metal. (It is lettered "Bessemer" in the figure.) Instead of turning over and discharging all its contents at the end of the spasm of violent combustion, or "blow," as in the Bessemer process, the Hollway Bessemer is fixed, and its action is continuous. The "slag" (I use this word under protest—it should be "cinder") of course floats on the top of the metal, and overflows into the settling basin, and from thence into the slag waggons, as shown in the figure; and when the metal reaches the mouth of the crucible that also flows into the basin, from which it is tapped as this basin fills.

The arrangements of the two blasts—one below for effecting the combustion of the sulphur in the midst of the metal, as the silicon and carbon are burnt in the Bessemer converter; and the cold blast above for starting the condensation and increasing the flue draught—are shown and explain themselves in the figure; also the flue which carries the sulphur vapour into the sulphur chambers on the left, where the condensation is completed. The partitions, *p p*, increase the length of the journey of the outgoing vapours, and afford additional surface for the condensation of the sulphur, which deposits itself on the chamber walls in the usual crystalline form of crude sulphur.

It is obvious that "lead houses" and other ordinary sulphuric acid plant may be added to this, in order to utilise the 14 or 15 per cent of sulphurous acid that otherwise escapes by the chimney, this sulphurous acid being identical with that produced in the kilns of the vitriol-makers by roasting pyrites.



We have here an English invention which, at first, is likely to be better appreciated abroad than at home, seeing that it offers such special advantages in countries that have rich deposits of sulphides, but little or no coal.

The smelting of copper appears to afford the widest field for

Mr. Hollway's operations, the most important ores of that metal being sulphides, and they commonly occur far away from coal-fields.

One of the merits claimed for this process is, that it is applicable to the working of very poor as well as very rich ores, or, as a preliminary operation, for obtaining the regulus of mixed ores, such as those containing copper, nickel, cobalt, silver, &c. This is of considerable importance, inasmuch as there are vast quantities of such poor ores in mountain and other regions of difficult access, which ores, on account of their large bulk in proportion to the metal they contain, will not bear the cost of carriage to this country for smelting. If, however, the metal can be brought into the state of a crude regulus, or semi-metallic mass, by this operation of self-supporting combustion, the regulus will be sufficiently valuable to bear the cost of transport to Swansea, or any other metallurgical centre where the fuel and other requisites required for its final purification are abundant.

W. Mattieu Williams.

ANALYSES OF BOOKS.

Stanford's Compendium of Geography and Travel. Based on Hellwald's "Die Erde und Ihre Vœlker." "Australasia." Edited and extended by ALFRED R. WALLACE, F.R.G.S. With Ethnological Appendix by A. H. KEANE, M.A.I. London: E. Stanford.

THIS volume, unlike the rest of the series to which it belongs, consists almost entirely of new matter, the account of Malaysia, Australia, and the Pacific Islands, as found in Hellwald's original work, being far too meagre. It can scarcely be necessary to say that to bring up the treatise to a level with the expectations and the wants of the British public no more competent editor than Mr. A. R. Wallace could have been found, specially qualified as he is by prolonged travels in a large portion of the islands described.

The work embraces an account of the Malay Archipelago,—taking the term in its widest sense,—of Australia proper, of New Zealand, and of the island-groups extending to the eastward more than half-way across the Pacific. These regions, though in actual land-area little exceeding Europe, extend in longitude over more than one-third the circumference of the globe, and present diversities both of physical features and of organic life hardly to be found elsewhere.

After a general survey of the peculiarities—geographical, geological, botanical, and ethnological—of this extensive region, the author proceeds to a systematic account of the several islands, beginning with Australia proper as the largest and most important. As may be expected, the natural history of the country is described briefly, yet with great care and evident accuracy. It may interest the reader to know that one species of *Eucalyptus*, growing about 40 miles to the east of Melbourne, is the largest tree in the world, surpasssing even the far-famed Wellingtonias (Sequioas) of California. A fallen specimen of the length of 480 feet has been actually measured. Such a tree, if it could grow in St. Paul's Churchyard, would wave its crest high over the cross at the summit of the cathedral. It is remarkable that the alpine flora of Australia contains thirty-eight species not merely representative of, but actually identical with, forms now occurring in Europe. The plants of Australia are by no means so exceptional as its animals. No widely distributed order is absent from Australia, and, on the other hand, no leading Australian order is wanting in the rest of the world. Sir Joseph D. Hooker, in his interesting treatise on the Flora of Australia, suggests that its antecedents may have inhabited an area to the

westward of the present Australian continent, and that the three southern floras—the Antarctic, Australian, and South African—may all have been members of one great vegetation which may once have covered an area as large as that of Europe.

It is interesting to notice that, as far as Australia is concerned, the epoch of subsidence in the southern hemisphere has passed its maximum, and that elevation has been traced at various places along the coast.

It must not, however, be supposed that the entire work is devoted to strictly scientific considerations. Both as regards Australia and the smaller islands we have full accounts of the progress of discovery and colonisation, of commerce, agriculture, and mining.

In the account of Borneo Mr. Wallace once more pays a well-merited tribute to the memory of the late Sir James Brooke, and triumphantly refutes the vile calumnies that have been again vented against him, both in and out of Parliament. Never before was a ruler, alien in race, language, and religion, so beloved by his subjects. He has left behind him, as Mr. Wallace truthfully observes, "over the whole of northern Borneo, a reputation for wisdom, for goodness, and for honour, which will dignify the name of Englishman for generations to come."

Our author, it must be noted, is—not without reason—somewhat sceptical as to the propriety and prudence of suddenly forcing our civilisation upon simple and ignorant populations. The general results of such attempts is that a few merchants and planters accumulate large fortunes, whilst harmless races are "improved off the face of the earth."

Perhaps the only point upon which we must differ from Mr. Wallace is where he, arguing from Java to England, recommends irrigation. He forgets, we fear, that in our climate—where evaporation as compared with rainfall is at a minimum—water, instead of being, as under the brilliant suns of tropical or semi-tropical regions, the one thing needful to ensure fertility, is with us, in average seasons and for our most important crops, the great cause of the farmer's troubles.

We need proceed no further with our survey of this most valuable book. Were we to notice even a tithe of the important facts which it contains we should fill up an entire issue of the "Journal of Science." It may truly be said of Mr. Wallace that "*Nihil tetigit quod non ornavit.*" The present work will only extend and enhance the reputation he has already won.

A Treatise on Chemistry. By H. E. Roscoe, F.R.S., and C. Schorlemmer, F.R.S. Vol. II., Metals (Part 2). London: Macmillan and Co. 1879.

We have already reviewed two parts of the work which concludes with the volume before us, and we can only repeat what we then

said, that all students will welcome the work of Professors Roscoe and Schorlemmer as a masterly treatise on the newest discoveries and the most recent methods of modern chemistry. This concluding volume contains lucid descriptions of the metals of the iron, chromium, tin, antimony, and gold groups. Three supplementary chapters are devoted to spectrum analysis, —a subject in which Prof. Roscoe is one of the foremost and most successful workers,—the natural arrangement of the elements and the periodic law of Mendeleef, and an account of the processes employed by MM. Pictet and Cailletet for the liquefaction of hydrogen, oxygen, and other gases which have hitherto been considered permanent. No pains have been spared to perfect the descriptions of the various technical processes by the aid of beautifully executed engravings. There are, in our opinion, several inaccuracies in the nomenclature, and of course a few clerical errors; but the work has, notwithstanding these, been most carefully prepared, and will take a high position as a standard chemical treatise.

A Manual of Palæontology for the Use of Students. With a General Introduction on the Principles of Palæontology. By H. Alleyne Nicholson, M.D., D.Sc., &c. Second Edition, revised and greatly enlarged. Edinburgh and London: W. Blackwood and Sons.

We have great pleasure in welcoming a second edition, revised and enlarged, of Dr. Nicholson's excellent Manual. All the more important discoveries made from 1872 down to near the end of 1878 have been incorporated in the work; the section on Stratigraphical Palæontology has been entirely omitted, as requiring to be dealt with separately; and the number of illustrations has been greatly increased. The features remaining unchanged are the spirit of accuracy and thoroughness, and the sound judgment which pervade all of Dr. Nicholson's writings. We can hence recommend him to the student as a safe guide, who, whilst always willing and ready to theorise upon a well-ascertained basis, never gives too free rein to the imagination, or seeks to be wise beyond what is demonstrated. In an age given to rash speculations such a teacher is invaluable.

The remarks on the conclusions to be drawn from fossils should be read and re-read by the young geologist. It is exceedingly important that so highly-disciplined and judicious a thinker as Dr. Nicholson considers that the existence of man may be traced back to the Post-pliocene, possibly even to the Miocene, Age.

Studies on Fermentation, the Diseases of Beer, their Causes, and the Means of Preventing them. By L. PASTEUR. A Translation made with the author's sanction, by F. FAULKNER and D. CONSTABLE ROBB. London: Macmillan and Co.

THIS work is an English version of Pasteur's well-known "Etudes sur la Bière," a work whose scope is far wider than its title would convey. In addition to a scientific examination of the process of fermentation, in the ordinary sense of the word, and to the application of the principles arrived at to the practice of brewing, the author surveys all those chemical changes—whether in dead or living matter—which are due to the operation of certain minute organisms. He shows further that this fermentative character may, under a certain well-defined condition, belong to every animal or vegetable cell.

The question of abiogenesis, or so-called spontaneous generation, is also touched upon. But in these days there is really very little need for Pasteur and Tyndall to demonstrate, by special experiments, that where all germs or spores are rigorously excluded life fails to manifest itself, even in the most favourable medium. Commerce is every day making the experiment on a far wider scale, and always with one uniform result. Millions of tins of preserved meat, milk, fruits, vegetables, soups, &c., are stored up for a length of time, and are conveyed half round the globe. Yet when opened they are invariably found free from low organisms, save when air has by accident or negligence been allowed to penetrate. If it is objected that the temperatures to which the contents of such vessels have been subjected has rendered them unfit for the support of bacteria, vibriones, &c., we need merely open a tin and expose it to the air, when we shall soon find it swarming.

Hence we hold that refutations of Dr. Bastian are scarcely necessary.

The work will be of very great value to English brewers, though we do not believe that they will be prevailed upon to adopt Pasteur's favourite system of bottom fermentation, nor that the British public would thank them if they did.

CORRESPONDENCE.

DO BIRDS FEED ON BLACKBERRIES AND RASPBERRIES?

To the Editor of The Journal of Science.

SIR,—In your notice of the Proceedings and Report of the Royal Society of Tasmania (vol. i., third series, p. 755) I quote as follows:—"The question was raised whether birds ever feed upon the blackberry or raspberry. With Mr. Spicer, we think that they do not in Europe, but we are by no means certain." In my garden (Sunbury, Middlesex) the blackbirds and thrushes carry them off in thousands. So voracious are they that unless disturbed they would carry off the whole crop. I have seen them jump at the trees, and carry off the fruit. Such good judges are they that the ripest and best are sure to be selected. I can therefore say, whatever may be their habit in other parts of Europe, if it be as you and Mr. Spicer seem to think, my raspberries are exceptions.

S. B.

ACADEMIES AND SOCIETIES.

ROYAL SOCIETY, *January* 15.—The papers read included one entitled "Results of and Inquiry into the Periodicity of Rainfall," by G. M. Whipple, B.Sc., F.R.A.S., Superintendent of the Kew Observatory. The exceptionally heavy rainfall of the past spring and summer directed a large amount of attention to the records of rainfall in this country, and more than one investigator stated that he had found a certain periodicity existing in the quantity of rain annually collected. Dr. Meldrum, Prof. Balfour Stewart, Mr. Hennessey, Prof. Stanley Jevons, Dr. Hunter, and others, have also widely published theories based upon the assumption that the variation in the yearly amounts of fall depends in some manner upon solar phenomena as exhibited by the changes in the appearance of the sun's surface, thereby indicating a cycle of approximately ten or eleven years' duration; but even amongst the supporters of this so-termed "sun-spot" theory of rainfall there are differences of opinion as to the exact nature of the influence an increase of sun-spots would exert upon the rainfall of any locality. Mr. G. J. Symons,* has partially investigated these theories, and shown the ten-year period does not obtain universally. With a view of dealing with the largest mass of material possible, the author took the long series of rainfall observations made at Paris from 1689 to 1875, published by M. Marie Davy, in the "Annuaire de l'Observatoire de Montsouris." Starting with an assumption of a period, which he first made five years in length, and subsequently extended, he grouped all the observations together, first in five-year groups, then in six-year, then in seven-year, and so on, year by year, until he reached thirteen years. The means of these furnished a set of curves, showing the variation from the mean in the amount of annual rainfall for each of the years composing the series under consideration. The author's results lead him to conclude that all predictions as to rainy or dry years, based upon existing materials, must in future be considered as utterly valueless.

PHYSICAL SOCIETY, *January* 24.—Mr. Grant read a paper and exhibited experiments on "Induction in Telephonic Circuits."

* Nature, vol. vii., p. 143.

Herr Faber exhibited his new speaking machine, which is designed to imitate mechanically the utterances of the human voice by means of artificial organs of articulation made on the human model, and actuated by an operator who depresses certain keys, as in playing a musical instrument. The organs are a bellows made of wood and india-rubber, which answers to the lungs; a small windmill placed in front of the latter, to give the "r" or trilling sounds; a larynx, made of a single membrane of hippopotamus hide and india-rubber, to give the "drone" or basic tone of the voice; a mouth with two lips; a tongue; and a nose or proboscis, made of india-rubber tubing placed below the mouth, but curving up towards it. Fourteen distinct vocal sounds can be uttered by the instrument, but in combining these any word in any language can be played by the keys. Thus Herr Faber caused his machine to say such words as "Mariana," "Eliza," "Philadelphia," "Constantinople," and various sentences in French, English, and German, more or less distinctly. Laughing and whispering were also produced, and the voice of the instrument, which was ordinarily loud and clear, and resembling that of a girl, was lowered in pitch and loudness to a more masculine tone.

NOTES.

Mr. D. Winstanley has described to the Manchester Literary and Philosophical Society a new instrument for recording sunshine. A differential thermometer with a long horizontal stem—in which latter is contained throughout the greater portion of its length some fluid intended to operate by its weight—is attached to a scale beam or some equivalent device which also carries a lead pencil by means of which the record is made. The whole is so arranged that in its normal state it rests gently—upon that side to which the pencil is *not* attached—on an embankment provided for that end. Close beneath the pencil point a disc of metal rotated at the proper speed carries a paper dial whereon marks and figures are engraved corresponding with the hours at which the sun may shine. When using this instrument it is enclosed within a box which permits one bulb only of the thermometer—that most distant from the clock—to be affected by the radiance of the sun, which when it shines expands the air contained therein, forces the fluid along the tube, and by altering the equilibrium of the beam brings some portion of its weight to bear upon the pencil point, and so the record is commenced. When the sun becomes obscured, the air expanded by his rays contracts, the fluid in the tube returns, the normal equilibrium is restored, and the pencil ceases to produce its mark. The stem of the thermometer is 18 inches long and about the eighth of an inch in bore. Mercury, in consideration of its weight, is the fluid Mr. Winstanley employs, and in conjunction with it some sulphuric acid is enclosed, because of the mobility which is thereby gained. The bulbs of the thermometer are 2 inches in diameter or thereabouts, and that they may be more rapidly affected the glass thereof is thin. Both are blacked, and the one intended to receive the radiance of the sun projects above the box in which the apparatus is contained into a dome of glass.

At a subsequent meeting Capt. Abney, R.E., F.R.S., exhibited his photographs of the ultra-red portions of the solar spectrum, and first of all showed that the light transmitted by ordinary bromide of silver was of an orange tint, showing absorption in the lowest end of the spectrum. He then explained how he had tried to load the molecules comprising this bromide of silver by means of gum resins, and that he had thus been enabled to photograph slightly beyond the lowest limit of the visible spectrum. Further researches proved that bromide of silver could be prepared in two molecular states—one that already

shown, and the other in which absorption takes place in the red as well as in the blue. This was found sensitive to every radiation. He pointed out that the blue form of the silver bromide could be converted into the red form by simple friction, and that after friction it was insensitive to the ultra-red radiation. Prof. Roscoe here exhibited the different preparations of gold in minute division made by Faraday himself, some of which transmitted blue light and others red, showing that at all events two cases of molecular condition exist in the case of metallic gold. Capt. Abney then threw upon the screen photographs of the prismatic spectrum, in one of which the lowest limit of the prismatic spectrum was reached. Various photographs of the ultra-red portion of the diffraction spectrum, extending from 7600 to about 11,000, were exhibited. Those from which Capt. Abney has made his final map were taken on double the scale, with twice the amount of dispersion. Capt. Abney showed various prismatic spectra, exhibiting different states of atmospheric absorption, in one of which Piazzi Smyth's rain-band was markedly visible. Some photographs of the spectrum in natural colours were also exhibited.

In many public aquaria, as at the Crystal Palace and Westminster, and also at that recently opened at the Aston Lower Grounds, near Birmingham, unchanged sea-water is employed; and such water has been found by experience to be fit for an almost indefinite period for maintaining marine animals in health. The principle adopted is to keep the bulk of the water in underground reservoirs, and to constantly pump from them a fresh supply into the show tanks, the delivery of the water being made through a series of fine jets. The great object of a constant supply, delivered in such a manner, is to force air along with fresh cool water into the tanks containing the animals. By that means the water is maintained of an almost constant temperature, and even if temporarily rendered cloudy by the presence of decaying fragments of food, &c., the rapid oxidation resulting from the air forced in along with the fresh water from the jets, soon renders the water quite clear. At Brighton and some other places the sea-water is intended to be used for a limited time only, a fresh supply being pumped in from the sea as often as required. Since it would be impracticable for inland aquaria to be supplied even at distant intervals with fresh sea-water, on account of the great cost incurred in collecting and for carriage, the system of unchanged water has of necessity to be adopted. Mr. H. Williams Jones examined a sample of water which, after being used for eight years in a large public aquarium, was quite bright, and appeared to answer perfectly the requirements of the animals. The results obtained we take from the "Chemical News," vol. xl., p. 282. It was inferred that a very large amount of nitric nitrogen would be present as a result of the

oxidation of the organic matter thrown off by the animals, or left in the water in the form of uneaten and unremoved dead food. As anticipated, a very large excess over what exists in actual sea-water fresh from the ocean was detected. The following figures show the difference between the aquarium-water and sea-water taken about the same date from Brighton, and which fairly represents the amount present naturally in sea-water.

	Nitric Nitrogen. Parts per 100,000.
Recent sea-water	0·0325
Aquarium-water	12·0498

In all well-stocked aquaria the number of living animals of a large size in relation to the bulk of water is greatly in excess of what exists in Nature; and the food of such animals kept in confinement instead of being produced in the water in which they live is received from an outside source in the shape of food formed in the ocean. The nitric nitrogen is formed in aquaria faster than it is removed by vegetation, which is usually limited to *confervæ*, and so it accumulates.

At the November Scientific Meeting of the Royal Microscopical Society, an improved form of Microtome (section cutter), contrived by F. H. Ward, M.R.C.S., was exhibited. The most noteworthy addition is the means of releasing the screw, when it is required to move the plug rapidly, thereby saving wear of the delicate screw, and also the time required in carrying the imbedded tissue through a long distance, either for removal or bringing to the top of the well. The bottom of the well is removable, and is retained in place by two bayonet catches. When removed from its fitting the bottom is separable into two halves, so as to release the screw: the continuity of thread in the internal screw is maintained in the two halves, when in position, by means of two metal pegs on the face of one half accurately fitting into holes on the face of the other. The screw has thirty-six threads to the inch, and is attached to a head having thirty-five notches on its circumference, into which a spring catch falls. The cutting surface is of plate glass, and can be removed at pleasure for the purpose of cleaning. The whole apparatus is extremely compact, and is provided with a screw clamp to fix it firmly to the table.

Mr. Crookes exhibited his experiments on Radiant Matter at the Ecole de Médecine, Paris, on the 8th and 11th ult.; at the Observatory on the 15th, and at the Société de Physique on the 16th of January.

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